3 Korea: Environmental Consequences of Rapid Economic Growth

Urbanization and Environmental Problems in Korea

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I. Urbanization and Environmental Challenge in Korea

The overpopulation of metropolis brings about the imbalance between regions in the national level and the living environmental problems such as the traffic congestion, the housing shortage, and the social problem such as crime in the city and regional level. The environmental pollution by industrialization increases in proportion to the production. The urbanization causes the concentration of population and industry, and affects the quality of life. The urban environmental problems show a difference according to the growth process and pattern of cities.

The Korean society right after the liberalization was plunging into a catastrophic end, which was attributable to several reasons like the socio-political disorder, the retreat of Japanese capital and technology, and the suspension of supply of electricity and materials from the North. Far worse, even before the institutional restructuring was made, most industrial cities, except Kyongnam Province and Taegu area, were destroyed during the three-year-long Korean War.

With the advance of foreign-aided economy after the war along with the rebuilding of the destroyed industrial facilities and cities, industrialization and urbanization faced a new phase. Especially the government's industrialization policies, from the beginning of the 1960s, may have had to take advantage of regionally unbalanced industrialization in an effort to use limited resources more effectively. Investment was primarily concentrated to such areas as Seoul-Kyonggi and southeastern part of the country including Pusan and Taegu, the areas which have relatively more favorable conditions of infrastructure as in roads, harbor, industrial water, energy source etc. They had been early developed as industrial bases under the Japanese colonial rule or excepted from the war destruction.

As a consequence, emerging as the center of industrialization, these areas brought about growing economic unbalance among regions, but also took a leading role in the process of urbanization. Regionally unbalanced industrialization policies in Korea are reflected on the population concentration and the advance of urbanization.

The major characteristics in this period of urbanization include overpopulation of urban areas, overgrowth of urban population due to the inflow of expatriates abroad and war refugees from the North, population concentration on big cities, especially on Seoul, population movement into city areas which was made with no relation with industrialization and unbalanced development of urbanization. The purpose of this paper is to describe the present condition of the urban environmental problems which are caused by urbanization, and to present the major policy agenda and recommendations for urban environment management in Korea.

2. Urbanization in Korea

2.1 The Urbanization Trends

Korea's urbanization can be divided into three phases: ① Period of Japanese colonial rule in 1910 - 1945, ② Period of partition and recovery after the war in 1945-1950, ③ Period of economic growth through genuine industrialization after the 1960s.

Korea's urbanization under the Japanese colonial rule can be divided into two stages: the first half in 1910-1934, and the latter in 1935-1945. In the first half of the period, harbor cities were primarily developed to take Korean crops and other materials into Japan, and also to bring in Japanese industrial products and other foreign goods.

Japan designated 12 cities in Korea, 10 of which, except for Seoul and Taegu, were harbor cities. Considering the time of Korean peninsula which was a typical agricultural society and most population inhabited inlands around farming fields, this concentrated development of harbor cities must have been intentionally planned by Japanese colonial policy. In the year of 1930, there were 14 cities in all in Korean peninsula and the whole population in urban areas was 1,189,791, which indicates only 5.6% of urbanization.

The points of the Korean urbanization policy in the latter half of the period (1935- 1945) were: first, fostering densely-populated inland cities, second intensifying the basis of colonial rule by renewing provincial capitals into administrative cities, third, building new industrial cities which can be functioned as military bases in preparation for invasion of China. By 1944, as a result, the number of cities had risen up to 21, where the whole urban population reached 3,411, 542 and urbanization rate 13.2%.

The most eventful period in Korean history experiencing the division of national territory and the Korean War, these memorable years witnessed the growth and development of cities which are closely related with national population movement. The partition of Korean peninsula, which concurred with the liberation from the Japanese rule brought in a total sum of 4,4 million people, 2.8 million expatriates abroad and 1.6 million refugees from the North, 29.6% of whom settled in cities. The whole population inflow, which caused a drastic hike in the population of big cities like Seoul, Pusan, Taegu, Masan, and Taejon.

In the meantime the Korean War, which occurred in 1950, produced the large number of 5.5 million war refugees, 1.5 million of whom flowed into the South. Consequently the number of cities rose from 14 to 25 during the period and the urban population in 1946 right after the war marked 2,831,926 representing quite big 14.6% of urbanization rate, which increased to 5,281,432 showing urbanization rate 24.5% in 1955. Korea's city growth pattern in this time period, however, was largely influenced by socio-political factors, quite different from those of developed western countries which accompanied economic maturity.

Table 1. Urbanization Trend of Korea, 1925～1995

Year	National total Population	Urban Population	number of legal cities	urbanization rate(%)
1925	19,522,945	850,157	12	4.4
1930	21,058,305	1,189,791	14	5.6
1940	24,326,327	2,818,460	20	8.6
1944	25,917,881	3,411,542	21	13.2
1946	19,369,270	2,831,926	14	14.6
1949	20,188,641	3,474,172	15	17.2
1955	21,526,374	5,281,432	25	24.5
1960	24,994,117	6,998,844	27	28.0
1966	29,192,762	9,806,812	32	33.6
1970	31,469,132	12,955,265	32	41.6
1975	34,708,542	16,793,980	35	48.4
1980	37,436,315	21,434,116	40	57.3
1985	40,466,577	26,458,170	50	65.4
1990	43,410,899	32,308,970	73	74.4
1995	44,606,199	38,247,813	73	85.7

It must be the marvelous economic development which has had a close relationship with Korea's urbanization process since 1960. The per capita GNP in the beginning phase of industrialization which hadn't exceeded $105 at the year of 1965 increased seventy-four times higher in 1995, thirty years later. In addition, 63.3% of the whole population who were engaged in the primary industry in 1965 decreased in a great extent up to 12.4%, while the rate engaged in the secondary and tertiary industry marked great increase from 8.7% to 28.2% and from 32.9% to 54.7% respectively at the same time period.

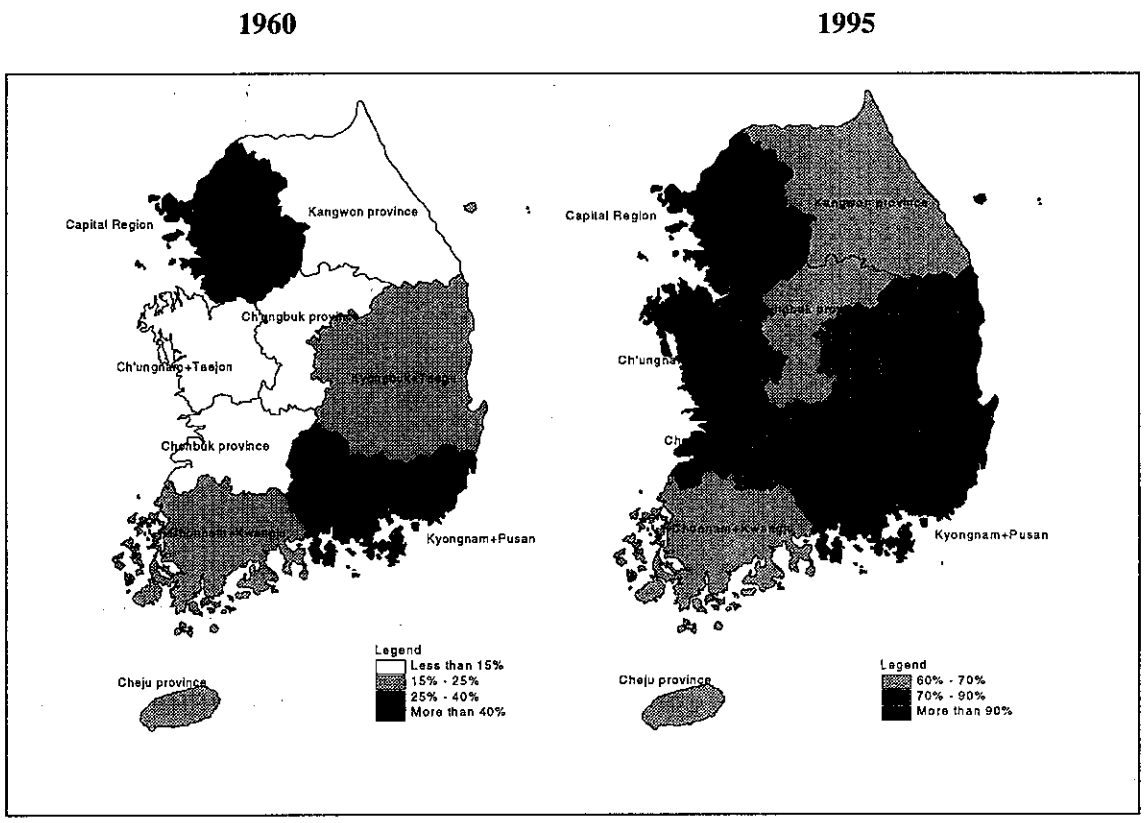
Along with this, in the process of active industrialization around the urban area, Korea also witnessed,as developed countries did, a big scale of population movement from rural areas, which still belonged to agricultural society. In other words, from this time, industrialization began to act as a pulling factor,which stimulated population movement from the country to the city greatly contributing for the advance of urbanization process. The urbanization process in 1960 as low as 28%, or the population of 6,998,273 in 27 cities, was dramatically hiked into 85.7% of urbanization or 38,247,813 of population in 73 cities in 1995.

In terms of national population share, the importance was raised 2.2 times from 20.9% to 46.6% in theCapital Region, and 2.4 times increase from 9.8% to 23.8% in Seoul alone. The population share of Seoul is slightly decreasing from the height of 24.4% of 1990, however.

Except the Capital Region, there were only a few areas which exceeded the average population increase rate(78.5%): Kyongnam-Pusan area with 83.3% of increase, and Cheju Island Province which experienced 79.4% of increase rate compared with 1960 or 224 thousand more people recorded. Other areas like Kyongbuk-Taegu area and Chungnam-Taejon had only slight increases of

33.1% or 1.27millionand 20.3% or 0.51 million respectively. On the other hand Chungbuk Provincial area didn't see any population growth in the past 35 years, while other areas like Kangwon, Chonbuk, and Chonnam-Kwangju recorded even minus growth at 10.4%, 20.6%, and 6.4% respectively.

Figure 1. The Level of Urbanization by Region



These findings lead us into a conclusion that the macro-change in population distribution in Korea in the past 35 years since 1960 is: ① The population was mostly concentrated on two mega-cities of Seoul and Pusan under the pulling force of the two cities. ② There was a slight population increase in Kyongbuk-Taegu area and Chungnam-Taejon, under the influence around the pivot of Seoul-Pusan connected. ③ Other areas except Cheju Island, which specializes in tourism, experienced an absolute population decrease.

2.2 Major Characteristics of Urbanization

In 1950, farmers who gave up farming concentrated on the large cities by the return to city of refugeesof the Korean War and the rural population's movement to cities. Therefore the urbanization of Koreain the 1950s is not by the pulling factors of cities, but the pseudo-urbanization that population concentrates on city by pushing factors that are the anxiety of rural society and the loss of living basis. The pseudo-urbanization caused the economic problem such as the structural unsoundness of the tertiary industry caused by weakening of economic basis and the surplus labor and the increase of

workers in the informal sector, the social problems such as unemployment and earning differentials.

In the Korean economy of the 1960s, the aspect of urbanization changed by starting the high rate of economic growth which is a result from the economic development plan. Cities grew quickly by the increase of employment opportunities by industrialization and the increment of inflow of rural population to cities.

From 1960 to 1970, the population of cities grew 5.3%, which exceeds the population growth rate of whole country, 2.1%. For this period, the cities that have the population of more than 1million population increased from 2 to 3 and the cities that have the population of 0.5-1million increased 1 to 8. The reason of rapid growth of metropolis is because concentration of population and capital and city-oriented development policy. The metropolis has accelerated growth. This trend of city growth means the appearance of megalopolis or primate city. The excessive concentration at Seoul caused the negative results such as the traffic congestion and environmental pollution. Therefore the characteristics of urbanization in Korea in the 1960s is that the city growth was achieved by industrialization policy, based on the manufacturing industry.

In the 1970s the process of urbanization in Korea became dull in the speed of growth. In the 1970s the cities experienced the most rapid growth are Pusan and outskirts of Seoul such as Incheon, Suwon, Sungnam, Anyang, and Pucheon. This rapid growth of the outskirts caused the serious environmental problems. The degree of air pollution in the year of 1978 showed that SO_2 at Seoul is 0.049, Pusan 0.047, Incheon 0.049ppm, which is exceeded 0.04ppm, the environmental criterion of Japan. On the other hand, industrial structure of Korea belongs to the high pollution industry. The heavy and chemical industry like the primary nonferrous metals, the primary steel manufacture and petroleum refinery made a serious affect in the environmental pollution. The proportion of air pollution increased rapidly from 11.2% in 1965 to 40.8% in 1973. Therefore, the Korean government tried to regulate the population concentration on the capital region for the purpose of population distribution. On the basis of this logic, the Ministry of Construction announced "Metropolitan population dispersion policy" in 1972, and drove forward reallocation of industry policy. In spite of the increase of national income by rapid economic growth and positive housing construction policy, the housing problem in Korea was serious. The problem was shortage of houses, low quality of houses, the low proportion of one's own houses, and inferior houses.

In the late 1980s, the supply plan of 2 million housing was established as the urgent goal of city policy and large-scaled housing complexes were arranged with the new town construction at surrounding area of Seoul. But as supplying houses came to the front as the first goal of city policy, it conflicted with the existing urban planning. The distortion of urban spacial structure happened. From the 1980s the number of cars increased rapidly, which affected living environment in a road congestion, traffic jam and accident, air pollution, noise and the deterioration of urban landscape. In addition to, huge parking lots took away the good space for people.

In the 1990s urban environment became worse because the urban area was replaced by the high density, high rise reconstruction and rebuilding. Urban infrastructure became more deficient. The

quantity-oriented development method that supply uniform apartments in large quantities, disregarding the urban landscape and characteristics of topography brought about the unbalance of the cities. In addition to this, the downtown reconstruction limited to office buildings didn't harmonize with the urban history. Reconstruction and rebuilding limited to the large scaled housing complexes caused negative result such as the social stratum and the similar architectural pattern.

The 1990s was the period that the influence of development policy spreaded to the deterioration of rural environment. The allowance of the high development area in farmland induced the 15-20th floor apartment in rural area, which is result in destroyed rural culture. Land use control is relieved during the IMF system and the unplanned development of land became serious. The greenbelt in 14 cities that functioned positively to urban environment for the last 30 years is mediating for the periods of 1999-2000. In 1999 greenbelt in 7 small-to-medium cities was released and greenbelt in the remaining 7 metropolis will be rearranged in the year of 2000 by urban planning. Green spaces in surrounding areas of cities will be disappeared by the rearrangement of greenbelt and it will seriously affect at the urban environment such as an air and water quality.

3. Conditions of Urban Environmental Problems and Policy Agenda

The target areas for current environmental situations in Korea are 7 major cities such as Seoul, Pusan, Taegu, Inchon, Kwangju, Taejon, Ulsan. When it comes to water environment, it is analyzed based on water system. Their current situations are reviewed in terms of five sectors - water quality, air quality, wastes, environmental debate, green space. In the water quality sector, water quality at the main points of the 4 major rivers, bayous, lakes, drinking water, and the coast are analyzed. In the air quality sector, the trend of discharge quantity of air pollution, the discharge amount of air pollution in the cities, the degree of SO_2, the degree of particles, the degree of CO, the degree of NO_2, the degree of O_3 are analyzed. In the waste sector, the trend of the amount of waste discharge and the trend of wastes are analyzed.

3.1 Water Quality

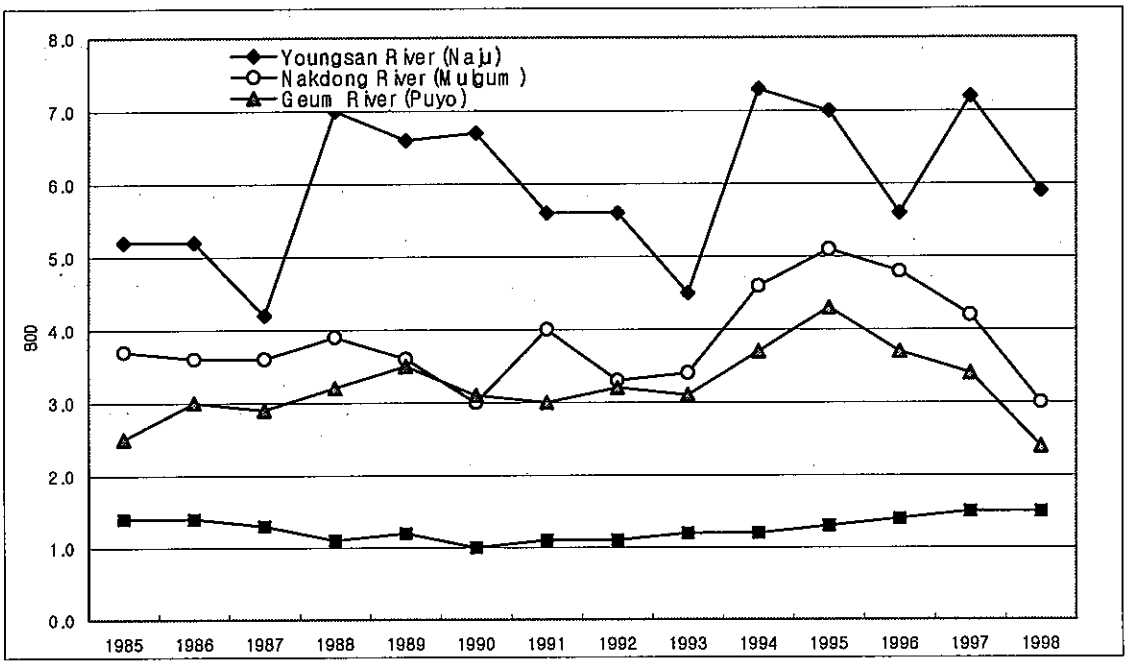
3.1.1 Water quality at the main points of the major 4 rivers

Table 2. BOD of the main points of 4 rivers

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Youngsan River (Naju)	5.2	5.2	4.2	7.0	6.6	6.7	5.6	5.6	4.5	7.3	7.0	5.6	7.2	5.9
Nakdong River (Mulgum)	3.7	3.6	3.6	3.9	3.6	3.0	4.0	3.3	3.4	4.6	5.1	4.8	4.2	3.0
Geum River (Puyo)	2.5	3.0	2.9	3.2	3.5	3.1	3.0	3.2	3.1	3.7	4.3	3.7	3.4	2.4
Han River (Paldang)	1.4	1.4	1.3	1.1	1.2	1.0	1.1	1.1	1.2	1.2	1.3	1.4	1.5	1.5

source: The Ministry of Environment(2000), The Environmental Data Book.

Figure 2. BOD of the main points of four rivers



From 1993 to 1995, due to the recurrent droughts of every 30 years, the amount of water had an absolute effect on water quality. The water quality has begun to be recovered since 1997. This is understood as a result of the efforts to improve water quality such as establishment of environmental basic facilities, etc. In 1998, the water quality of Youngsan River, Nakdong River, Geum River is shown to be much improved, compared to that of the 1997 year.

In comparison with water quality of each river, it was found that Youngsan River has the worst water quality and Han River has the best water quality, followed by Geum River and Nakdong River. The water quality of Nakdong River shows a big difference by the year, and that of Han River maintains constant water quality. Nakdong River and Geum River show the similar trend of water quality difference. The BOD of these rivers increased until 1995, and then decreased. This can be understood as a result of the drought from 1993 to 1995 and the establishment of environmental basic facilities after the period.

The main four rivers don't maintain the 1st degree water quality. Among them, Han River still keep the 2nd degree water quality. Nakdong River and Geum River had the 3rd degree water quality in the early 1990s, and their water quality has been improved to the 2nd degree in recent years. The water quality of Youngsan River, which has a big difference by the year, was the 3rd degree, and sometimes the 6th degree which is inadequate for the resource of drinking water.

In comparison with the difference of water quality of an upper and lower stream in 1998, the water quality is determinated by the location of Metropolitan Areas. In case of Han River, the water quality

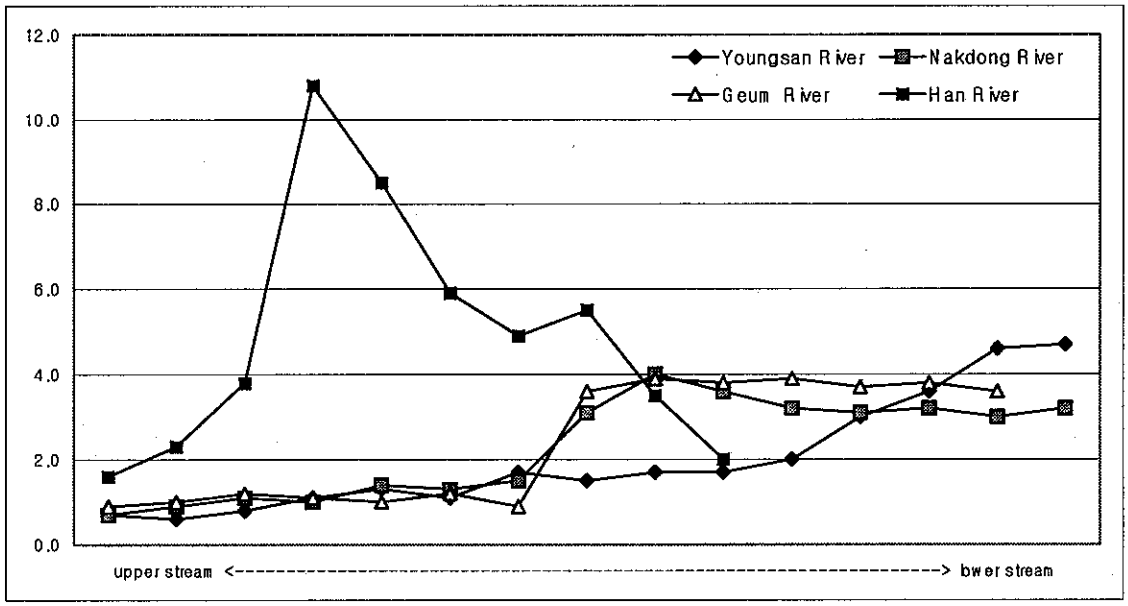
declined to the 3rd degree from the districts of submarine barriage of Jamsil. In case of Nakdong River, the water quality was worsened to the 3rd degree while passing Daegu City. In case of Guem River and Youngsan River, the water quality was tremendously deteoriated while passing Daejon City and Kwangju City. When it comes to water quality of lower stream, Youngsang River was the best, followed by Nakdong River, Geum River, and Han River.

Table 3. Water quality of an upper and lower stream of the 4 major rivers

	upper stream <----------> bwer stream														
Han River	0.7	0.6	0.8	1.1	1.3	1.1	1.7	1.5	1.7	1.7	2.0	3.0	3.6	4.6	4.7
Nakdong River	0.7	0.9	1.1	1.0	1.4	1.3	1.5	3.1	4.0	3.6	3.2	3.1	3.2	3.0	3.2
Geum River	0.9	1.0	1.2	1.1	1.0	1.2	0.9	3.6	3.9	3.8	3.9	3.7	3.8	3.6	
Youngsan River	1.6	2.3	3.8	10.8	8.5	5.9	4.9	5.5	3.5	2.0					

source: The Ministry of Environment(2000), The Environmental Data Book.

Figure 3. Water quality of an upper and lower stream of the 4 major rivers



3.1.2 Water Quality of River

As shown in Table 3, the lower parts of the four rivers are the higher COD. Exceptionally, Go-ryung of Nakdong River and Naju of Youngsan River have the worse water quality in upper than lower stream. Among the measured points, Goryung and Ansung Bayous has the high COD. The annual trend of these locations, COD has rapidly been lowered at Goryung since 1995, and Ansung Bayous in 1997.

Table 4. COD and BOD of the major rivers

		1990		1991		1992		1993		1994		1995		1996		1997		1998	
		COD	BOD	COD	BOD	COD	BOD	COD	BOD	COD	BOD	COD	BOD	COD	BOD	COD	BOD	COD	BOD
Han River	Euam	1.6	1.3	2.2	1.6	1.8	1.4	1.7	1.5	2.1	1.5	2.8	1.5	2.5	1.5	2.7	1.6	2.7	1.3
	Chungju	1.7	1.1	1.1	0.9	1.5	1.1	1.6	1.0	1.9	0.9	2.4	1.0	2.3	0.9	2.0	0.8	2.3	0.8
	Paldang	1.8	1.0	1.7	1.1	1.7	1.1	2.1	1.2	2.6	1.2	2.9	1.3	2.8	1.4	3.1	1.5	3.1	1.5
	Noryangjin	4.7	3.4	5.0	3.9	4.5	3.6	4.3	3.1	4.9	3.3	5.5	3.8	5.8	3.9	6.4	4.1	5.0	3.6
	Kayang	5.3	4.7	5.5	4.8	5.3	4.3	5.7	4.0	5.8	4.3	6.7	4.4	7.6	5.0	8.3	5.5	6.3	4.6
Nakdong River	Andong	2.0	1.0	2.4	1.1	2.5	1.1	2.5	0.9	3.1	0.9	3.3	1.2	2.8	0.9	3.6	1.1	3.3	0.9
	Goryung	7.6	5.4	8.7	5.8	8.4	5.4	7.9	4.5	10.2	5.9	12.4	7.3	9.1	5.8	8.8	5.1	6.1	3.1
	Nam ji	5.3	3.2	6.3	4.3	6.6	3.8	6.5	3.8	9.4	5.4	9.7	5.7	8.9	5.2	8.5	4.7	6.2	3.2
	Mulgeum	5.3	3.1	6.5	4.0	6.2	3.3	5.9	3.4	8.9	4.6	9.5	5.1	9.2	4.8	8.5	4.2	5.9	3.0
	Gupo	5.1	3.3	6.5	3.7	6.3	3.5	6.5	3.9	8.8	4.6	8.9	4.7	8.7	4.4	8.3	3.8	6.1	3.2
Geum River	Okchun	1.5	1.5	1.6	1.6	1.6	1.4	2.1	1.4	2.7	1.4	2.7	1.3	2.6	1.2	2.7	1.1	2.7	0.9
	Daechung	1.9	1.7	1.9	1.6	1.8	1.6	2.2	1.6	2.8	1.5	3.0	1.2	3.5	1.5	3.2	1.2	3.2	1.0
	Chungwon	3.0	3.1	3.0	3.1	3.2	2.9	3.7	2.7	4.1	3.3	6.6	4.7	5.8	3.8	5.6	3.6	4.6	2.3
	Gongju	3.1	3.2	3.0	3.1	3.6	3.3	4.0	3.1	4.7	3.7	6.9	4.8	6.0	3.8	6.3	3.7	5.3	2.5
	Puyo	3.0	3.1	2.9	3.0	3.5	3.2	4.1	3.1	4.6	3.7	6.5	4.3	5.8	3.7	6.0	3.4	5.0	2.4
Youngsan River	Dam yang											2.7	1.5	2.1	1.4	3.5	1.6	4.7	1.6
	Uchi	2.3	1.2	2.6	1.1	4.1	1.4	3.6	1.4	5.3	2	3.3	2.3	3.6	2.1	6.1	2.5	5.9	2.3
	Kwangju	5.8	3.4	4.6	2.8	6.3	3.4	5.7	2.6	8.4	3.3	5.1	3.6	4.6	3.8	6.2	4.5	5.9	3.8
	Naju	7.4	6.7	6.9	5.6	7.3	5.6	7.0	4.5	9.6	7.3	9.1	7.0	6.3	5.6	7.8	7.2	8.2	5.9
	Muan	4.1	1.2	4.4	1.5	4.9	2.1	5.4	1.5	6.4	1.9	5.7	2.6	4.0	2.0	6.1	2.2	5.8	2.0
Ansung Bayous	Ansung Bayous3			8.7	7.5	7.9	8.4	9.2	7.5	8.5	6.3	10	11	11	9.7	11	8.8	9	8.3
Sapgyo Bayous	Sapgyo Bayous2			5	4.7	4.5	4.3	5.4	4.5	5.4	3.6	7.1	4.5	5.6	4.5	7.7	4.1	6.2	3.7
Dongjin River	Dongjin River1											2.3	1.1	3	1.4	3.2	1.1	3	1.1
Tam jin River	Tam jin River1			1.5	1.1	1.9	1.1	1.6	1	1.7	1.3	1.5	1	1.9	1.2	2.9	1.1	2.3	1.1
Taehwa River	Ulju	1.8	1.2	2	1.2	2.6	1.2	2.4	1.2	3.1	1.5	3.3	1.3	3.5	1.2	3.9	1	3.1	1.2
Hyungsan River	Hyungsan River2			4.1	2.4	4	2.4	5	2.8	8.5	5.2	9.9	6.9	8.1	5.9	9.6	5.4	4.7	2.7

source: The Ministry of Environment(1999), The Environmental Year Book.

However, the annual trend of BOD was not obviously indicated. The COD of Ansung Bayous has been much worse, though BOD has been lowered since 1995. Like COD, BOD is shown to be higher in lower stream, but there are some areas where the BOD is higher at Go-ryung of Nakdong River, Naju of Youngsan River.

3.1.3 Water Quality of Lake

Table 4 shows the annual COD trend of lakes. In table 4, COD of some lakes seems to be increased gradually, but the trend is not obvious. Wholly, it is shown that Youngsan River, Mankyung Bayous, and Sapkyo Bayous have higher COD. Among them, the high COD of Ansung Bayous shows that the water pollution is serious. For lakes, there has never had the 1st degree since Chungju Dam showed 0.9, which means the 1st degree in 1991. Also, Ansung Bayous and Sapkyo Bayous showed the 6th degree which is inadequate for the resource of drinking water.

Table 5. COD of the major lakes

		1990	1991	1992	1993	1994	1995	1996	1997	1998
Han River	Whachun Dam	2.4	2.0	1.9	1.3	1.6	2.5	1.5	1.9	1.7
	Soyang Dam	3.5	2.4	1.7	1.6	1.5	1.8	1.8	1.9	2.0
	Euam Dam	1.6	2.4	1.9	1.7	2.1	2.7	2.3	2.7	2.4
	Chungpyung Dam	2.5	2.2	2.4	1.6	2.1	2.8	2.1	2.5	2.3
	Paldang Dam	2.1	2.1	2.0	2.1	2.5	3.0	3.1	3.5	3.0
	Chungju Dam	2.0	0.9	1.7	1.5	1.8	1.9	2.1	2.1	2.4
Nakdong River	Andong Dam	2.2	2.8	2.0	2.1	2.1	2.0	2.4	2.6	2.7
	Imha Lake				2.7	2.8	2.7	2.4	2.4	3.0
	Youngchun Dam	2.4	2.6	3.1	3.1	3.0	3.2	3.2	3.5	3.6
	Namgang Dam	3.4	2.8	2.4	2.6	2.9	2.5	2.8	2.8	2.7
	Hapchun Dam	3.6	3.9	2.2	2.0	2.0	1.9	1.7	2.1	2.3
Geum River	Daechung Dam	1.8	2.0	2.1	2.0	2.1	2.3	2.5	3.2	3.2
Youngsan River	Damyang Dam	3.5	3.1	2.6	2.8	3.0	2.6	3.0	3.4	3.4
	Jangsung Dam	3.9	4.1	4.2	4.1	3.7	2.7	3.3	4.4	4.6
	Naju Dam	5.0	4.2	3.5	4.3	4.0	3.1	5.5	4.8	4.9
	Youngsan Lake	5.0	4.8	4.9	5.4	6.1	5.2	4.2	5.9	5.8
Sumjin River	Sumjin River	3.5	3.0	2.5	2.2	2.1	2.3	2.5	2.7	2.6
Mangyung River	Kungchun Lake	4.0	3.5	3.6	3.1	4.1	5.5	6.1	4.8	6.5
Ansung Bayous	Asan Lake	9.0	10.6	10.4	8.7	8.8	10.8	8.4	8.0	8.5
Sapgyo Bayous	Sapgyo Lake	4.9	6.2	6.0	5.9	4.9	6.9	7.9	9.1	6.6

source: The Ministry of Environment(1999), The Environmental Yearbook.

3.1.4 Quality of Drinking Water

The excessive rate of drinking water is shown to be the highest in a small watery. The excessive rate in a mineral spring water is shown to be the secondly highest, and that of a water service is 1.3~3.3%. The excessive rate of a small water has decreased since 1995, and that of a mineral spring water tremendously decreased in 1993, but has been on the similar trend due to the increase of 1996. stagnant water factory has maintained low excessive rate.

Table 6. The result of examination of the quality of drinking water

	1992		1993		1994		1995		1996		1997		1998	
	exam.	excess of standard	exam.	excess of standard	exam.	excess of standard	exam.	excess of standard	exam.	excess of standard	exam.	excess of standard	exam.	excess of standard
public water supply plant	1,056	22(2.0%)	1,092	16(1.5%)	1,106	18(1.6%)	1,105	36(3.3%)	1,137	26(2.3%)	1,147	26(2.2%)	1,142	26(2.2%)
tap water	1,216	38(1.5%)	2,253	44(1.7%)	2,523	32(1.3%)	2,513	45(1.9%)	2,545	37(1.5%)	3,112	51(1.6%)	3,271	43(1.3%)
small water	335	49(16.7%)	289	67(23.1%)	591	123(20.8%)	590	170(28.8%)	590	113(19.2%)	601	123(20.4%)	601	92(15.3%)
mineral spring water		499(19.8)	2,767	229(8.2%)	2,984	270(9.0%)	3,183	286(9.0%)	6,275	855(13.6%)	6,603	874(13.2%)	6,691	746(11.1%)

source: The Ministry of Environment (1999), The Environmental Year Book.

3.1.5 Water Quality of the Coast

The annual trend of water quality on the coasts, shows the great difference, depending on the locations where they are measured. The COD is shown to be higher on the coasts of Gunsan, Pusan, and Ulsan. Also, it drastically increased on the coasts of Onsan and Ulsan in recent years. On the coasts of Sungsan, Samchok, and Seogwepo showed rather a low pollution level.

Table 7. COD of the major coasts

	1991	1992	1993	1994	1995	1996	1997	1998
coast of Incheon	1.6	1.5	1.5	1.4	1.6	1.6	1.6	1.5
coast of Asan	1.4	1.3	1.3	1.4	1.2	1.3	1.3	1.0
coast of Daecheon	1.6	1.6	1.5	1.5	1.4	1.2	1.2	1.5
coast of Gunsan	2.2	2.3	2.7	2.0	2.0	2.2	1.6	1.8
coast of Mokpo	1.8	1.8	1.9	2.0	1.9	1.7	1.4	1.8
coast of Jindo	1.3	1.2	1.2	1.2	1.6	1.2	0.7	0.9
coast of Wando	1.5	1.4	1.4	1.3	1.4	1.1	0.7	0.9
coast of Yeosu	1.6	1.8	1.5	1.5	1.4	1.4	1.4	1.8
coast of Namhae	1.0	1.1	1.2	1.2	1.3	1.3	1.2	1.6
coast of Tongyoung	1.7	1.2	1.4	2.1	1.8	1.7	1.7	2.0
coast of Geoje	1.1	1.2	1.5	1.3	1.4	1.5	1.0	1.6
coast of Jangseungpo	1.8	1.2	1.9	1.5	1.3	1.6	1.4	1.6
coast of Pusan	1.6	1.2	1.7	2.2	2.2	1.9	1.9	1.7
coast of Sungsan	0.5	0.7	0.6	0.6	0.8	1.3	0.8	1.3
coast of Seogwipo	1.4	1.3	1.5	1.5	1.5	1.5	0.7	1.3
coast of Onsan	1.6	1.5	1.9	2.2	2.0	1.6	2.6	2.1
coast of Ulsan	1.9	1.7	1.8	1.8	2.0	1.5	2.3	1.8
coast of Samchuk	2.0	1.7	1.7	1.4	1.6	1.4	0.7	0.7
coast of Donghae	0.8	1.0	1.3	1.2	1.3	1.4	1.1	0.8
coast of Sokcho	2.1	2.0	2.0	1.9	1.6	1.8	1.5	1.4

source: The Ministry of Environment(1999), The Environmental Yearbook.

The water quality on the coasts of Jindo and Wando has recently been improved to be the 1st degree. The water quality on the coast of Sungsan has maintained the 1st degree except 1996. The others haveall kept the 2nd degree water quality though the water quality on the coast of Gunsan worsened to the 3rd degree in the early 1990, but has been improved to be the 2nd degree in recent years.

3. 2 Air Quality

3.2.1 The Trend of Air Pollutants discharge

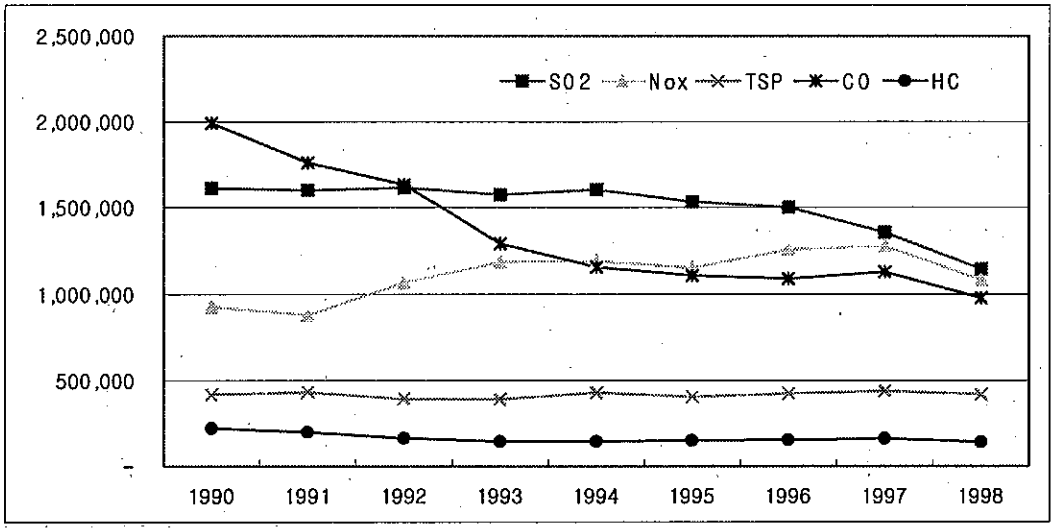
Despite of the growing oil consumption, discharge of air pollutants has rather been rather decreased the total discharge of the pollutants due to the extension of supply of unpolluted fuel, lead-free gasoline,green mode, and so on. Particularly, discharge of SO_2 has been decreased. However, due to the rapid growth of automobiles, discharge of NOx has been gradually increased.

Table 8. Air pollutant discharge

	sum	SO2	Nox	TSP	CO	HC
1990	5,169,119	1,610,960	926,065	420,318	1,991,065	220,711
1991	4,869,959	1,597,780	878,389	431,375	1,759,505	199,910
1992	4,867,637	1,613,549	1,067,001	392,243	1,630,378	164,466
1993	4,583,839	1,571,700	1,186,697	389,750	1,290,527	145,165
1994	4,526,250	1,602,764	1,191,533	429,398	1,156,464	146,091
1995	4,349,606	1,532,320	1,152,765	405,526	1,109,097	149,898
1996	4,424,546	1,500,260	1,257,993	423,694	1,088,788	153,811
1997	4,364,723	1,356,395	1,278,348	438,531	1,129,092	162,357
1998	3,768,000	1,146,000	1,084,000	420,000	977,000	141,000

source: The Ministry of Environment(2000), The Environmental Data Book.

Figure 4. Air pollutant discharge



3.2.2 The amount of all pollutants at major cities

The discharge amount of all kinds of pollutants except for SO_2 is the most at Seoul. In particular, the discharge amount of CO and NOx is shown to be tremendously high. This is attributed to the large number of automobiles. In Pusan, the SO_2 gas has been discharged especially much compared to the other cities. In Daejon and Kwangju, all kinds of pollutants have been discharged less than those in Seoul, Pusan, Daegu and Inchon.

Table 9. The amount of all pollutants at major Korean cities

	sum	TSP	SO2	CO	HC	NOx
sum	4,364,723	438,531	1,356,395	1,129,092	162,357	1,278,348
Seoul	388,342	14,895	22,514	215,211	29,531	106,191
Pusan	352,012	14,644	152,606	88,964	14,281	81,517
Taegu	127,925	6,843	16,749	58,826	8,136	37,371
Incheon	219,579	9,646	53,692	62,221	9,664	84,356
Kwangju	57,892	2,634	4,078	30,365	4,007	16,808
Taejeon	62,917	2,717	7,365	31,395	4,253	17,187

source: The Ministry of Environment(2000), The Environmental Data Book.

3.2.3 Pollution level of SO_2 of the main cities

Table 10. Pollution level of SO_2 of major Korean cities

	Seoul	Pusan	Taegu	Incheon	Kwangju	Taejeon	Ulsan
1984	0.066	0.050	0.040	0.056	0.026	0.028	0.024
1986	0.054	0.042	0.043	0.053	0.020	0.027	0.032
1988	0.062	0.044	0.052	0.056	0.019	0.019	0.028
1990	0.054	0.039	0.041	0.044	0.017	0.029	0.031
1991	0.043	0.038	0.041	0.041	0.017	0.028	0.038
1992	0.035	0.033	0.040	0.036	0.017	0.022	0.031
1993	0.023	0.028	0.035	0.021	0.014	0.020	0.032
1994	0.019	0.023	0.038	0.022	0.013	0.021	0.030
1995	0.017	0.023	0.031	0.023	0.010	0.017	0.028
1996	0.013	0.022	0.023	0.012	0.008	0.015	0.022
1997	0.011	0.018	0.016	0.013	0.009	0.011	0.019
1998	0.008	0.015	0.014	0.009	0.008	0.009	0.015

source: The Ministry of Environment (2000), The Environmental Data Book.

A pollution level of SO_2 exceeded annual environmental standard value, 0.03ppm in the major cities except Kwangju before 1990, but has gradually decreased due to the supply of lead-free gasoline and the obligation of the use of unpolluted fuel since 1990. Particularly, the pollution level of Seoul was reduced from the maximum of 0.094ppm in 1980 to 0.062ppm in 1988, 0.019ppm in 1994, and 0.008ppm in 1998. Most cities except Seoul achieved WHO recommendation level, 0.015~0.023ppm after 1996. Ulsan, where many discharge factories are crowded has high pollution level compared to the othercities. However, the average pollution level of the whole area was 0.015ppm in 1998, and was maintained to be the lower level than the environmental standard. In other main cities including Ulsan, the pollution level of SO_2 has never exceeded the short-term environmental standard since 1997.

3.2.4 Pollution Level of TSP in the Main Cities

As shown in Table 11, the pollution level of TSP was on the decrease from 1986 to 1998. In Seoul, it has continued to be decreased from 183 $\mu g/m^3$ in 1986 to 150 $\mu g/m^3$ in 1990, 57 $\mu g/m^3$ in 1998,

which is less than the annual environmental standard, 150 $\mu g/m^3$. In 1998, the pollution levels were 74 $\mu g/m^3$ in Pusan, 72 $\mu g/m^3$ in Daegu and 64 $\mu g/m^3$ in Daejon. All these are less than the annual environmental standard, 150 $\mu g/m^3$.

Table 11. Pollution Level of TSP in major Korean cities

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
Seoul	183	175	179	149	150	121	97	88	78	85	85	72	57
Pusan	194	197	214	178	140	134	113	96	97	93	89	84	74
Taegu	140	146	155	128	134	109	119	105	93	73	75	62	72
Incheon	153	163	162	152	170	144	103	100	93	93	86	86	81
Kwangju	133	105	100	116	109	100	104	75	64	63	74	74	62
Taejon		175	178	119	115	68	52	53	58	69	63	67	64
Ulsan	172	190	238	165	122	104	102	98	99	97	106	84	72

source: The Ministry of Environment (2000), The Environmental Data Book.

3.2.5 Pollution Level of CO in the Main Cities

The pollution level of CO in the main cities has been slowly lowered. Inchon recorded the highest pollution level before 1995, but the pollution level has rapidly been on the decrease lately. The pollution level was very low in the early 1990s in Daejon, but has become the highest in recent years. Largely, itwas the lowest in Ulsan.

Table 12 Pollution level of CO in major Korean cities

	Seoul	Pusan	Taegu	Incheon	Kwangju	Taejon	Ulsan
1991	2.2	1.5	1.8	2.6	1.9	1.5	1.3
1992	1.9	1.1	1.6	2.2	1.5	1.1	1.1
1993	1.5	1.3	1.2	1.8	1.3	1.2	1.2
1994	1.5	1.6	1.1	1.6	1.2	1.4	1.1
1995	1.3	1.0	1.0	1.8	0.9	1.2	1.3
1996	1.2	1.2	1.0	1.3	1.1	1.4	1.0
1997	1.2	1.0	0.8	1.2	1.2	1.4	0.9
1998	1.1	1.0	1.0	0.8	0.9	1.4	0.7

source: The Ministry of Environment (1999), The Environmental Year Book.

3.2.6 Pollution Level of NO_2 in the Main Cities

The pollution level of NO_2 was on the increase by 1996, and then has been gradually on the decrease. It was the highest in Seoul, where the annual difference wasn't obvious, keeping it 0.03ppm. The pollution level in Taejon and Kwangju was the lowest. It has never been over the environmental standard, 0.05ppm.

Table 13 Pollution Level of NO_2 in major Korean cities

	Seoul	Pusan	Taegu	Incheon	Kwangju	Taejon	Ulsan
1991	0.033	0.023	0.021	0.030	0.013	0.018	0.024
1992	0.031	0.023	0.030	0.034	0.012	0.014	0.026
1993	0.032	0.025	0.024	0.030	0.017	0.014	0.026
1994	0.032	0.024	0.023	0.029	0.022	0.019	0.026
1995	0.032	0.027	0.028	0.032	0.020	0.021	0.023
1996	0.033	0.031	0.027	0.033	0.021	0.023	0.023
1997	0.032	0.028	0.024	0.026	0.021	0.022	0.023
1998	0.030	0.024	0.027	0.026	0.016	0.018	0.019

source: The Ministry of Environment(1999), The Environmental Year Book.

3.2.7 Pollution Level of Ozone in the Main Cities

The pollution level of Ozone in all the main cities is gradually on the increase. The level is higher in Pusan and Kwangju, while Inchon and Ulsan show lower level of pullution.

Table 14 Pollution level of Ozone in major Korean cities

	Seoul	Pusan	Taegu	Incheon	Kwangju	Taejon	Ulsan
1991	0.012	0.014	0.010	0.013	0.013	0.009	0.015
1992	0.014	0.015	0.013	0.016	0.017	0.010	0.013
1993	0.013	0.014	0.013	0.012	0.015	0.011	0.014
1994	0.014	0.014	0.015	0.014	0.015	0.014	0.014
1995	0.013	0.016	0.017	0.013	0.016	0.015	0.015
1996	0.015	0.020	0.015	0.011	0.017	0.017	0.015
1997	0.016	0.019	0.015	0.016	0.021	0.018	0.015
1998	0.017	0.022	0.017	0.016	0.022	0.018	0.017

source: The Ministry of Environment (1999), The Environmental Year Book.

3. 3 Wastes

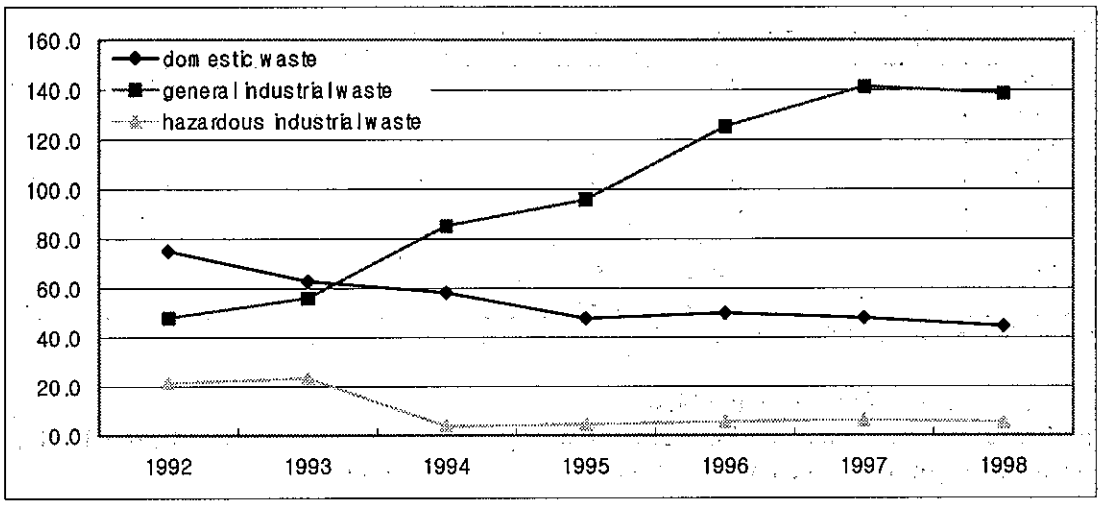
3.3.1 Trend of Wastes Discharge

The total amount of wastes in Korea has gradually been on the increase since 1993. While domestic wastes and the hazardous industrial wastes are gradually on the increase in the 1990s, general industrial wastes show high increase rate of more than 10% every year. The industrial waste has been more than domestic wastes since 1993.

Table 15 Amount of waste discharge

		1992	1993	1994	1995	1996	1997	1998
sum		144.5	141.4	147.1	148.1	180.8	194.7	188.6
wastes		75.1	62.9	58.2	47.8	49.9	47.9	44.6
factory wastes	sum	69.4	78.5	88.9	100.3	130.9	146.8	144.0
	general	48.0	56.0	85.2	95.8	125.4	141.3	138.7
	designated	21.4	23.4	3.7	4.5	5.5	6.1	5.3

Figure 5 Amount of waste discharge



3.3.2 Trend of the difference of domestic wastes

The amount of domestic wastes per person was 1.3kg per day in 1994. With such governmental policies as waste-quater system in 1995, it was reduced to 0.96kg per day in 1998. It reached the similar level to 0.96kg of England and 0.99kg of Germany. The total amount of wastes was the highest in Seoul, followed by Pusan, Daegu, and Inchon. It was slightly increased in 1996, and has been decreased since then. Also, the amount of waste discharge per person was the highest in Seoul. It was the highest in Kwangju in 1998. It was rather low compared to other major Korean cities.

Table 16 Amount of household waste discharge

	discharge amount (ton/day)				discharge amount per person (kg/day)			
	1995	1996	1997	1998	1995	1996	1997	1998
Korea	47,774	49,925	47,895	44,583	1.07	1.11	1.05	0.96
Seoul	14,102	13,685	12,662	10,765	1.33	1.31	1.22	1.04
Pusan	4,280	4,311	4,146	3,893	1.09	1.10	1.07	1.01
Taegu	2,720	2,652	2,745	2,563	1.10	1.06	1.10	1.02
Incheon	2,041	2,147	2,057	2,097	0.89	0.91	0.85	0.85
Kwangju	1,514	1,461	1,546	1,492	1.18	1.13	1.18	1.13
Taejon	1,276	1,325	1,488	1,351	1.02	1.04	1.14	1.02
Ulsan			1,238	1,050			1.26	1.05

source: The Ministry of Environment (1999), The Environmental Year Book.

3.4 Environmental Debate

Table 17 shows the number of environmental debates in the main cities. Seoul has 76 out of 252 casesequivalent to 30%, and Kyunggi area has 58 cases equivalent to 23%. The cases of Seoul Metropolitan Areas including Kyunggi area occupy 53%.

Table 17. Environmental Debate

	before 1994	1995	1996	1997	1998	sum
Seoul	14	5	20	15	22	76
Pusan	2		4	3		9
Taegu	2	1				3
Incheon	1	5	1	3	8	18
Taejon		2	1		1	4
sum	19	13	26	21	31	110
Korea	63	30	50	47	62	252

source: The Ministry of Environment (2000), The Environmental Data Book.

3.5 Green Space

Seoul occupied the largest green space in total amount, but Ulsan occupies the largest green space per person, followed by Kwangju. The reason why Ulsan has the largest green space per person is because much of the green space which belongs to Ulsan City in terms of administrative districts, was included. Actually, green space is far from the downtown.

Table 18. Area of green space

	Uba Planning District (1000m 2)	Population (1000 person)	neborhood parks			public green area				urban green space (neborhood + public)		
			area	area rate (%)	per capita area (m 2)	total	buffer green space	view green space	per capita area (m 2)	area	area rate (%)	per capita area (m 2)
Korea (79 cities)	10,275,620	43,170	289,262	2.8	6.7	58,959	53,814	5,145	1.4	348,221	3.4	8.1
7cities total	3,905,240	22,877	118,299	3.0	5.2	20,845	18,686	2,159	0.9	139,144	3.7	6.1
Seoul	605,950	10,389	35,466	5.8	3.4	2,074	1,954	120	0.2	32,540	6.2	3.6
Pusan	750,910	3,865	26,402	3.5	6.8	5,804	5,272	532	1.5	32,206	4.3	8.3
Taegu	693,010	2,501	11,576	1.7	4.6	4,081	3,104	977	1.6	15,567	2.2	6.2
Incheon	393,670	2,460	10,300	2.6	4.2	2,182	2,056	126	0.9	12,482	3.2	5.1
Kwangju	478,370	1,326	13,456	2.8	10.1	2,232	2,092	140	1.7	15,688	3.3	11.8
Taejon	469,740	1,323	9,372	1.9	7.1	2,005	1,941	64	1.5	11,377	2.4	8.6
Ulsan	514,590	1,013	11,727	2.3	11.6	2,467	2,267	200	2.4	14,194	3.6	14.0

4. Basic Principles and Alternatives for the Sustainability

4.1 Basic Principles for the Sustainable City

There is an active effort being made to study how to develop sustainable cities and what the development techniques would be. Although controversial, urban sustainability could be explained from three aspects: resource-saving urban space development, building a comfortable living environment in harmony with nature, and open democratic society entailing residential participation.

The first principle of a sustainable city is the eco-city component. It is the plan of environmental city or eco-city which is suggested as an urban development strategy to realize cities where natural environment is properly preserved and utilized. Eco-cities have various, independent, stable

circulatory structure in terms of ecosystem, while properly preserving and utilizing the nature itself.

The goal of eco-city planning is to enhance urban sustainability and integrity not just to recover urban health by getting rid of pollution but to build a city with plentiful green area and bio-diversity in an alive bio-geo-chemical cycle of ecosystem. Needed for this purpose are such techniques as, eco-construction, waterfront design, eco-friendly land use planning etc.

The second principle of a sustainable city is the resource and energy saving cities. It is an urban space development planning which is expected to contribute for resource saving in energy use and transportation. The resource-saving urban spacial structure is to keep high urban density, since high density residential development can be highly energy-efficient. However, over-sized cities entails problems like high congestion and long distant commuting causing dis-economy of scale.

Accordingly, it can be desirable to disperse compact cities along the main traffic axis than to grow a single giant city. It can be named a development with decentralized concentration where functions of residence, workplace, and service are co-related with a certain amount of density. Moreover, using various natural conditions such as, winds, solar energy and circumstantial micro-climate conditions are recommended to use as an alternative for heating in city development planning and building construction.

The third principle of a sustainable city is the democratic participation process. The sustainable city development, in the socio-economic aspects, is to build cities where residential participation is guaranteed, social conflicts and tension can be easily solved, and autonomous self correction and renovation is possible. The sustainable city is capable to analyze and solve their own problems for itself, and so have flexible political, economical, administrative, technical system, and thereby can enhance their own capability and the living quality of residents.

Urban environmental pollution, which has high specialty and uncertainty, should be open to not only experts but ordinary citizens and be under enough discussion. The starting point toward a sustainable city would be effective participation of residents who are supposed to be polluters and also victims and to pay against the pollution. Cities can be said to be sustainable only when residential participation is guaranteed and information around development and preservation can be timely utilized. So that all the citizens including the future generation could be given at least the basic amount of natural-resources and the minimum level of environmental quality for safe living.

4. 2 Alternatives to Increase the Sustainability of Urban Area

4.2.1 The Establishment of Effective Urban Eco-Community

An urban eco-community should be desirably formed by groups related with urban matters such as community residents, industries, expert groups, NGOs, and local governments.

Urban residents, who are directly influenced by pollution, should be allowed to take part in the problem-solving process as a social pressure group. Because they are mainly victimized by

environmental pollution and are also forced to pay against the very pollution. Urban residents are advised to timely participate in the decision-making process in matters of development and environment. For this, urban administration should be open and readjusted to facilitate the residential participation.

Additionally needed to establish urban environmental community is an exact and accessible environmental information management system, which will cover a wide range of natural environment, socio-economic conditions, spacial placement of industry and population. Urban sustainability index also should be developed and used to assess urban sustainability and to remove obstacles on the way.

4.2.2 Comprehensive Urban Land Use Planning and Its Implementation

A comprehensive land use planning should be made taking into consideration all fields concerned such as, transportation structure, residential area location, industrial complex design, and environmental management policy etc. This will hopefully lead to accomplish a high quality urban structure and land use, with lessened environmental load and co-existence with nature .

This kind of urban planning is aimed at plentiful open space for comfortable urban life, successful urban functions, convenience. The consideration of regional characteristics concerning such aspects as proper use of due altitude is important in the formation of fair residential environment and the proper alignment of business functions. It also pursues decentralized concentration in urban development which disperse compact cities along with the main traffic axis. The compact cities could be connected by such public transportation as railway and electric railway and subway system etc.

It is necessary to devise a comprehensive measure covering both transportation and land use planning, building an eco-friendly transportation system to reduce traffic volumes and to lessen the environmental impacts of transportation in a fundamental way. The traffic system development should be to minimize the destruction of the nature and ecosystem, while contributing for harmony with the environment. Traffic congestion and stagnation as well as circuits should be put under control to serve for smooth traffic flows, minimized environmental pollution and pleasant living environment.

4.2.3 Intensifying Urban Natural Ecosystem Preservation Strategies

There should be an active drive for afforestation and natural harmony in urban areas. Natural ecosystem preservation planning should be established and executed in order to preserve bio-diversity. There should be categorized consideration over such matters as natural ecosystem to be preserved, bio-diversity to be improved, plentiful green areas to be ensured, and comprehensive afforestation techniques to be applied.

Green networks and eco-bridges are desirably constructed to preserve diversity and integrity in natural ecosystem. Various afforestation techniques could be introduced as on roofs, walls and roof-tops

ensuring naturality in the highly developed city area. Green buffer zones could be utilized as a counter-measure against air pollution and noise.

4.2.4 Intensifying Water Environment Preservation and Its Utilization System

In order to lessen environmental loads as well as to improve environmental quality, there should be more high quality waterfronts and green areas. The demand for water resources should be reduced, making water use and its saving more effective. It should be consistently pursued to build rainwater infiltration facilities, waste water recycling system, and natural water purification system etc. In addition, the basic environmental facilities such as drinking water and sewage system, sanitary facilities, waste water treatment facilities, solid waste treatment system should be supplied from the initial planning stage, pursuing preventive urban environmental management. Recycled water could be used to make waterways inside the urban area, providing urban residents with pleasant waterfront environment.

4.2.5 Building a Reasonable Resource and Energy Use System

Efforts should be made to reduce urban energy use while increasing its efficiency. Urban energy use will have to be approached categorically into natural energy use, efficient energy use, and reuse of waste heat and energy. Clean energy facilities like solar-energy buildings should be extendedly provided in a systematical way. Other essential projects will include consolidating air quality management system, planning and executing environmentally less harmful traffic projects.

Additionally desired projects are extensive supply of heat-combined power generating system and development of subway-connected transportation system so as to increase urban energy use efficiency and to promote resource recycle. Medium and small sized cities will need to build more bicycle-only roads in order to support the use of bicycles. Guaranteeing walkers' rights should be followed to promote bicycle use.

4.2.6 Increasing Environmental Friendliness of Urban Transportation

As a major pollutant source, urban transportation system should be concerned . To reduce air pollution from transportation, several measures could be preferably taken: extending bus-only lanes, regulating the total amount of parking space, regulating the use of vehicles (through introduction of congestion driving tax, passenger car tax, etc.). Attention should also be paid to several tasks like consolidating stagnated or congested areas, improving detours and circular road system, keeping street side environment and its preservation in order seeking harmony with the nature. Additional efforts should be made to intensify regulation against emission discharge from transportation, to activate the development of low-polluting vehicles possibly leading to environmentally friendly electric cars.

Railways transportation facilities like subways, electric railways, and monorails would have to be expanded and so would inter-public-transportation connection and transfer system, which will all contribute to the use of public transportation. Some other recommendations are to enhance the service of public transportation, to restrict the entrance of vehicles into the city center to increase the share of public transportation, and to encourage building bicycle-only roads in newly developed towns.

5. Policy Agenda and Recommendation for Urban Environmental Management

5.1 Major Policy Agenda for Urban Environmental Management

5.1.1 Coping with Environmental Problem Generated from Consumption Stages

Income increase owing to the economic development has drawn national attention to environmental quality but it is also changing the characteristic of environmental problems itself. The environmental pollution at the beginning stage of economic growth was mainly caused by pollutants generated in the production process, but now it is being changed into one caused by improved living conditions due to economic growth and income increase.

Increasing environmental problems are now attributable to the phenomenon called "Democratization of Privilege", which refers to privileges once monopolized by a small number of the rich, but now being enjoyed by more ordinary people. For example, the primary air pollutant is being changed from emission gas from factories and households to waste gas from automobiles. More water pollution is being generated by households and golf courses than by factories and agricultural land. More solid wastes are being made by homes and small-sized commercial places rather than by big business places, and so more varied and much less homogeneous as well as more poisonous.

This kind of pollution has resulted from increased level of national consumption and leisure activities, which indicates that pollution in our daily life matters more and that polluters are more universalized and diversified. That is, changing people's consumption patterns and cultures has become one of the most important policy agenda. Moreover, the deepening everyday-life pollution could possibly turn the government, which is the subject of environmental policy, into the object of environmental policy implementation. For instance, local governments should pay more attention in constructing and operating sewage and waste treatment facilities.

5.1.2 Securing Voluntary Compliance of Industries

What mattered in the 1970s and 1980s was to ensure 'Initial Compliance', which means how to oblige the polluters to equip themselves with environmental facilities. The environmental policy tasks in the 1990s, however, is becoming a matter of ensuring 'Continuous Compliance'; that is, how to induce them to sincerely maintain and operate the facilities constructed. It is a generally accepted notion that every polluter should be equipped with environmental facilities. It is a quite different matter to properly maintain and operate the already established facilities.

Constructing pollution control facilities costs a lot but at the same time operating and maintaining them cost additional big money. Enterprises, who thought that this kind of expense will not help increase their profit, would try to avoid financial burden as much as possible. Therefore ensuring Continuous Compliance, different from ensuring Initial Compliance, was a very hard and complicated task which the success of environmental policies will depend on. Nowadays policy tools to induce the adoption of voluntary environmental management and development of cleaner production technique become more important and urgent.

5.1.3 Overcoming Environmental Conflicts and Disputes

Environmental conflicts and disputes have been aggravated after the introduction of local autonomy. Phenomena like NIMBY ("Not In My Back Yard") and LULU ("Locally Unwanted Land Use"), the regional conflict over water use and preservation of water quality, and the designation and management of natural ecosystem conservation district tend to be even more increased.

There were 280 environmental disputes between 1990 and 1997, 134 of which were private between businesses and residents and the rest 146 were public-institutes-related. The most frequent regional environmental disputes were over the establishment and management of waste-treatment facilities, which was followed by water-related disputes. Disputes over air pollution and noise-vibration pollution werenot a few but limited to the private sector between businesses and victim residents.

This kind of environmental conflicts and disputes are based on various factors like lack of experience and culture for democratic decision making process, lack of environmental scientific technology and information which can satisfy increased national environmental awareness, accumulated distrust against development and environmental policies and administration. Therefore without reasonable mediation of environmental disputes, a successful local autonomy as well as a more advanced environmental management can not be possible.

5.1.4 Meeting the Demand of Global/Regional Environmental Issues

Korea's regional environmental management has to face challenges from global environmental problems and transfrontier pollution.

Northeast Asia is one of the most rapidly growing region in the world. Nations in this regions are very closely related each other causing transboundary pollution problems. Air pollutants, which cause acid rain and snow can move more than 2,000kms, causing transboundary air pollution problems among Northeast Asian nations. Water pollution in the Yellow Sea, East Sea, where water circulation is almost closed are also in jeopardy.

Moreover, Korea's cities must overcome the global pollution problems. It is expected that environmental regulations will get more intense and demanding worldwide under the increasing concern over explosive environmental pollution. Under fragile policy environment with highly

foreign-dependent economic system, the poor environmental industry and recycling structure, low level of environmental science and technology, Korea has to cope with international check and pressure. Korea's city governments, which have just stood idle at this globalized environmental situation, however, now have to foster capability to deal with the circumstances in the prospect to activate local economy and preserve environment more successfully.

5.1.5 Ineffective Intergovernmental Relationships and implementation problem

Korea traditionally has had a unitary governmental system in which the central government exercises most of the governmental powers. During the past three decades, Korea's governmental system, with its strong national government, has proved to be a pretty efficient system in mobilizing national resources for rapid economic development. The responsibilities for implementing environmental policies were given to local governments when the Environmental Conservation Act was enacted in 1977. When the Environment Administration established 6 regional environmental offices in 1986, however, the major tasks of enforcing environmental regulation were given to the regional offices.

After the phenol pollution accident in 1991, along with the mood of localization, all of the responsibilities of monitoring and enforcing environmental regulation devolved to provincial governments in 1992. From water pollution accidents at Nakdong and Youngsan Rivers in early 1994, the responsibilities implementing environmental policies began to be shared by both the Environmental Management Offices and provincial governments based on the location of emission sources. Emission sources located in industrial complexes acquire permits and are enforced by the Environmental Management Offices; the rest are enforced by provincial and / or local governments. Most environmental functions which have transferred from the MOE to Provincial governments have tranferred further to local (cities, counties, districts) governments. A survey shows that more than 60% Provincial governments transferred their rights to Local governments. Provincial and Local governments have various types of environmental administrative structures. However, since provincial and local governments do not have enough experience in environmental administration and since their discretion for organizational reform is very limited under the current Local Autonomy Act, their administrative structure and man power have many weakness. With their poor environmental resources, provincial and local governments could not properly implement the very complicated environmental regulation. For this reason, Korea could not handle environmental issue effectively although she has a very well-designed environmental policy framework.

5.2 Recommendations for Urban Environmental Management Policy

5.2.1 Building Effective Intergovernmental Relationships

The reform of environmental administration depends on reasonable role assignment between national and local governments, and between the government and the private sector. Sharing governmental responsibility through local autonomy is basically aims at a situation that policy formation and

planning is performed by national government while its implementation by local governments. Policy implementation can be more effectively carried out by local governmental units like cities, provincial offices, and counties, They are more closely related with the residents and can better reflect their opinions. The role of the national government is better to be limited to supporting and supervising the local government's performances, which will help foster expertise.

Environmental policies should have to allow local governments more autonomy over policy implementation, so that they get more rights and responsibilities for the environmental administrative reform. In establishing environmental standards and planning, executing the right of personnel management, and financial management, local governments should be given more rights. They should be allowed to take more active roles in unifying environmental administration functions, enforcing their ordinances and rules, and restructuring with intensifying institutional interaction and connection.

Local governments should be given more autonomy for financial management. That is, the policy implementation should be carried out by local governments in principle. The present categorical grant systems should be shifted into block grant style so that local government's own 'priority' is considered in the environmental policy making processes. National government, however, should hold a tight grip on conflict co-ordination and intensely critical environmental problems through their local branches.

The problem is, however, the great difference in the capability and willingness among local governments for environmental policy implementation. Here the transfer is recommended to be gradually made through the 'partial pre-emption' style. It is recommendable that the more capable local governments, for the moment metropolitan-cities, get earlier transfer of rights. Local governments which have insufficient regulatory resources and capability need to have intensified support from the national government. The support or regulation of the national government, however, should be given discriminatively on the basis of regulatory outcome. For this, the development and introduction of proper assessment system for local governments' environmental administration.

5.2.2 Reforming Administrative System using Market Principle

The national concern about environmental pollution is very high in Korea. The people's participation in the environmental policy process, however, is still very limited. Hence, more aggressive cooperation, supervise, and participation from community residents are required. In order to enhance democratic spirit and effectiveness, each local government should introduce environmental quality management system by such way as "Citizen's Environmental Charter" after setting up environmental acts.

Additionally required are advertisement of the activities of city councils and city governments, public hearings over city administrative performances, surveys on various local projects, and report system for complaints over environmental service, etc. Nowadays, environment-related information and

materials can be open to experts as well as the public by way of the Administrative Information Disclosure Act. There should also be more active alternative like Citizen's Legal Actions system. The civilian participation in the supervision over environmental pollution should be systematized incentives given to employees, consumers, and community organizations so that they could watch for the compliance of environmental regulations.

For the reform of ineffective administration of local governments, competitive elements of market economy could be positively used. The work sharing between governmental and market sectors should be based on market principle, that is profitability. To enhance the effectiveness of local governments, it is desirable to expand civilian participation in environmental service provision. Some ways of civil participation are privatization, contracting-out, public/private competitive process, etc. Privatization is a system that private companies run by civilians take charge of public service provision. Contracting-out is entrust private firms with temporary supply of public service within the contract term. Public/private competitive process is to decide through free competition between public institutions and private firms.

5.2.3 Introducing More Flexible but Integrated Regulatory System

It is necessary to settle down environmental regulation system according to regional environmental capacity. Under the present environmental regulatory system, the authorities can hardly manage environmental quality considering regional environmental capacity. Not a few regions, however, have been developed more than their receptive capacity or are trying to surpass their capacity. Thus, the reform of environmental regulations should guarantee more effective environmental management along with careful concern about environmental capacity. First of all, integrated regional impact environmental analysis, is necessitated to solve the present problem that even though each development project satisfies the regulatory requirements, the total environmental impact of the projects altogether can surpass the regional environmental capacity. The strategic environmental assessment system also needs to be set up so as to evaluate local governments' development policies, programs and plans.

More flexible regulatory system should be introduced to enforce strict environmental regulation but at the same time to lessen the burden of individual firms. The current strict process-centered-regulation should be changed into result-oriented observance management system. Another important regulatory reform task should be to establish more cooperative the relationship between the government and firms. It is also advisable that local governments and polluting firms make agreements along with the kind of businesses or the industrial areas in an effort to improve environment. Conglomerates and local governments, which are both important in local economy, are recommended to make an autonomous environmental management compacts in cooperating for the environmental improvement of local community.

Environmental regulations need to be changed from punishment-oriented ones to support/facilitation-oriented ones so that voluntary environmental management could be prevalent. To boost the

environmental compliance of small-and medium-sized industries, which don't have enough information and technological capability for environmental management, 'Environmental Management Home Doctor System for Small/ Medium-Sized Industries' could be recommended. Another recommendation is to hire experts as specialized high- ranking officials to activate technology-guidance-oriented environmental management. Firms in the same industrial area could be led and supported to form a joint environmental study and management team. Firms nearby should be led to cooperative environmental management through mutual exchange and support of information and technology.

5.2.4 Resolving of Local Environmental Conflicts Effectively

Intensive efforts should be made to reasonably mediate regional environmental disputes which are being aggravated since the advent of local autonomy. For the reasonable settlement of regional disputes requires three principles: first, clarification of the relationship between rights and responsibilities, that is delimitation of property right, second, fair sharing of costs and benefits among relevant stakeholders,third, solution finding through democratic negotiation based on established principles. Primarily there should be an effort to clarify the responsibilities between local and national. Besides, under the fair-share-principle, nationally-operated NIMBY projects should be compensated for the sake of the residents with more chances of beneficial facilities, employment opportunities, and income subsidies. In usingurban land, more positively aggressive attitude is needed so that favored facilities could be located along with unwanted ones.

In addition, regional environmental disputes should be overcome through fair interregional interest coordination, NIMBY through the induce of PIMFY(Please In My Front Yard) investment, the use of residents monitoring system, and advanced facility establishment and management. Along with this recommended are organizations of environmental councils and associations, which are voluntary cooperation systems among local governments. It is also necessary to enforce mutual cooperation system among local governments through financial, technological support. Another requirement is to intensify mutual investment and financial, technological supports to improve the effectiveness of the establishmentand management of environmental facilities. Additionally required are strict monitoring for polluters, individuals or firms. Community fee systems will be a useful tool for the easy settlement of regional environmental disputes regarding the location of unwanted facilities in the concerned areas.

Appropriate compensation for environmental pollution damage is important for both the realization of environmental justice and smooth implementation of environmental policies. For intense redemption for environmental damages the followings are necessary.

First, measures to recognize the victims' right of claim for environmental information and to make claims for damages smooth, for example as in formulating compensation standards, should be studied about. Second, national government and local governments should be given the right of claim for damages on natural environment. Third, the general rule called "for victim's interest when suspicious"

should be set up, lessening victims' burden of proof.

The introduction of environmental insurance system should be examined in order to make smooth compensation for environmental damages and to solve disputes over uncertain environmental damages in the future. To introduce environmental insurance system, there should be examination about such issues as, the standard of claims for compensation, the scope of compensation, burden of proof, maximum amount of compensation, etc.

6. Concluding Remarks

Korea's urbanization has been accelerated along with rapid economic growth since the 1960s and had caused various side effects. Urban environmental pollution is the one of the most serious side effects of the rapid urbanization in Korea. Many experts on urban problem worry about the unsustainability of cities in Korea. Accordingly, improving sustainability in the urban areas is the most important policy agenda towards new millennium.

Building the sustainable city in the new millennium of Korea should start from finding a unique identity of each city. Korea's cities and provinces lack their own distinguished characteristics. Without their own individuality, a very important quality which has been disregarded in Korea during the economy growth era, urban development has often ended in a simple imitation of other regions or failed big cities. Facing thee 21st century, an era of globalization and openness, will highly regard cultural and ecological identities which distinguish one from the others and which will in part facilitate a city toward more sustainable one.

Thus all urban constituents including politicians, governmental officials, NGOs, regional residents would have to cooperate to find out regional identity and uniqueness- natural, cultural, and historical- and take intensive care of it. In doing this, consideration should be taken not only for natural environmental, historical, cultural heritages and ecosystem and bio-diversity preservation but also for industrial characteristics of the city. For example, a city teeming with unique eco-resources could take advantage of the precious regional assets, by fostering tourist industry. A city with waste mines could use the deserted place for industrial or tourist purpose, preserving its characteristics and at the same time fostering related industries.

In conclusion, sustainable cities could be achieved only by urban constituents who are willingly to find their own identities - natural, cultural, historical - and put them on the basis of the development of regional economy and industry, finally combining all these with modern resource-saving urban structure. To make this happen, urban areas need to make aggressive efforts to preserve the nation and limited resources while taking good care of regional culture with intensive reformative capability to survive under the rapid changing international circumstances.

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Sustainable Development and DPSER Model: The Case of Ulsan Metropolitan City

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1. Economic Growth and Urban Environment in Korea

East-Asian countries have experienced rapid economic growth, industrialization, and urbanization. However, this rapid economic growth also has created several environmental problems in local, national, and even global level. And then, the current economic growth policy exposes some limitations in sustaining economic growth. So, there is a need to explore a new growth paradigm for the sustainable development. The experience of Korea's economic growth provides significant implication to East-Asian countries in many ways. Korea is one of the most successful countries in the economic development during the last forty years, while the country has been experiencing serious environmental problems due to negative impacts of a rapid economic growth. In particular, Ulsan Metropolitan City (UMC), which is one of the most representative cities in terms of economic growth and environmental pollution, paid lots of costs to cure these environmental problems and still is suffering from the environmental damages. And then she changed recently a growth strategy from an economic growth-oriented policy to a sustainable development in order to solve environmental problems. These changes result in the slight improvement in the environments. Therefore, Korean experiences, especially UMC's ones, will be helpful to solve environmental problems of other Asian cities.

This study reviews the Korean economic growth policies and environment policies, especially the economic development and environmental policies of Ulsan Metropolitan City. The objectives of this paper are to present innovative ideas and models to guide urban environmental management policies in the sustainability urban development. More specifically, it develops the assessment model for the sustainable development and it applies to the Ulsan Metropolitan City. For this objective, this paper develops the Driving Force -Environmental Pressure –Environmental States -Its Effects –Government Response (DPSER Model), following development stages. And using this model it also assesses economic growth and environmental policies of Ulsan Metropolitan City (UMC) in order to draw the sustainable development policy and get some lessons to apply to other developing cities.

2. Sustainable Development and Development of Analytical Model: DPSER Model

2.1 The Definition of Sustainable Development

It can be argued that anticipating and preventing problems is often proved better than trying to react

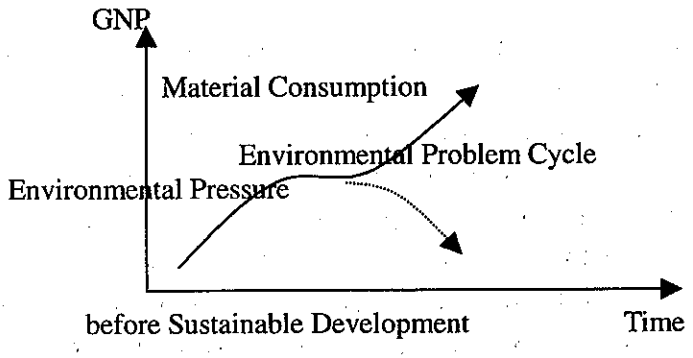
and fix them after they occur. The former is regarded the most popular approach of sustainable development in development economics. Since the United Nations' Conference on Humans and the Environment in 1972, the international concern concerning sustainable development has increased (Korea Environmental Technology Research Institute, 1993). The concept of sustainable development is suggested as an alternative approach to solving the conflict between economic growth and environmental preservation. Sustainable development can be defined in several ways. The following are some common descriptions:

> "Sustainable development meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations World Commission on Environment and Development, 1987)."
> "Sustainability refers to the ability of a society, ecosystem, or any such ongoing system to continue functioning into the indefinite future without being forced into decline through exhaustion . . . of key resources (Robert Gilman, 1998)."
> "It is the emerging doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense. It means that environmental protection and economic development are complementary rather than antagonistic processes (Ruckelshaus, 1989)."

2.2 Economic Growth and Environmental Degradation

Economic growth is closely related to the pressures on the environment in the industrial society because it causes several kinds of industrial wastes which are externalities of industrial development (Tisdell, 1993). The relation between economic growth and pressures on the environment can be illustrated as Figure 1 shows (Vellinga, 1998).

Figure 1. Economic Growth and Environmental Problems



Source: Velliga, Pier (1998: 2, Figure 2) (revised by author).

As a country develops from a mainly agriculture economy to an industrialized economy, its gross national product (GNP) grows, while the use of environmental resources simultaneously increases along with environmental pollution. Most developing countries experience the growing environmental problems as their economy expands, following the left side of the bell-shaped curve in

Figure 1. Industrialized countries have followed that path until about 1970. Meanwhile, social basic needs such as food and housing have been meted and the quality of life gradually has improved. However, in many cases, the environmental problems have grown worse. In order to solve these problems, human, financial and technical resources were invested in transforming industrial structure from the heavy-chemical industry to information technology and cleaning up of polluted industrial sites. And several environmental governance policies have also been adopted. As a result, the urban environment of some developed countries has significantly improved, moving downward along the right hand side of the bell-shaped curve, because the services and information economy requires less environmental resources and consumes less materials (IHDP, 1998). However, Korea is still on an increasing path of environmental resource use and materials consumption. If she does not change its industrial structure from heavy-chemical industry to high technology or does not take environmental governance policy, the environmental problem cycle will move upward along the right hand side of the bell-shaped curve. Currently, Korea is located at the turning point of the bell-shaped curve. Depending upon the adjustment of industrial structure or the adoption of environmental governance policies, its curve can move either upward or downward. Very recently, the UMC has especially been following the downward slope of the curve because she has successfully began to transform her industrial structures and has implemented environmental governance policies (UMC, 1997).

Sustainable development stresses active planned-regulation in the level of local governments at the time of city development. This kind of bottom-up development strategy necessitates conceding the decision-making right to the level of local governments in establishing and implementing public policies. Accordingly, in the principle of sustainable urban development, there have been growing and successful efforts made by local governments. The concept of sustainable urban development can be defined in various dimensions and is determined comprehensively by various factors. The concept of sustainable development should be considered comprehensively with various aspects from ecological, social, and economic views so that it can be applied to all fields of policies, planning, programs, and particular projects. With consideration of previous studies, this paper hereby defines the concept of sustainable city more precisely: sustainable city is the one that has accomplished ecological diversity, circularity, self-reliance, and stability. It is a city that allows both humans and nature to cohabit, decreases environmental load, and at the same time enhances the quality of life. On the basis of the concept of sustainable city defined here, this study is going to develop an assessment model for sustainable city.

2.3 Development of the Assessment Model for a Sustainable City

The concept on sustainability or sustainable development is still broad and ambiguous. Considering that the structure of a city is closely related with every element of a society, it could be very hard to assess a certain city's sustainability through the process of systematizing and modeling. Thus, this study intends to develop a more precise and practical city assessment model, using the Driving Force - Environmental Pressure –Environmental States -Its Effects –Government Response process (DPSER)

for the environmental sustainability. DPSER Module views a city as a systematic structure. In this module a city is understood as it responds to various factors like human activities, the amount of environmental load derived, environmental conditions due to the environmental load, the influence of changed environment, and human response to the change. To do that, several indicators will be adapted or developed.

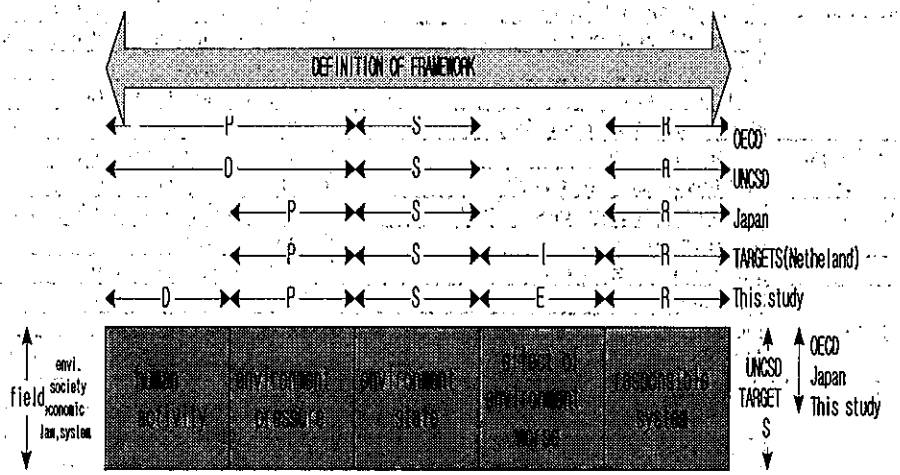
DSPER Module deals the most fundamental part of urban development assessment model. It is not long since indexes consisting of assessment models began to be used as effective standards and criteria for public policies. In the Conference of Environmental Ministries at the early 1990s, in the common approach to human-environment relationship, Organization for Economic Cooperation and Development (OECD) and United Nations Commission Sustainable Development (UNCSD) suggested systematizing Core-Set of Indicators taking PSR structure. PSR represents: first, pressure on the environment from emitted pollutants and dried up natural resources, second, change of state that such pressure causes, and third, response against all these. This has been the groundwork for the following index development projects worldwide. Since the necessity of index development was clarified on the chapter 40 of agenda 21 in Rio Summit in 1992, practical work was under way by Control Sustainable Development (CSD) and Policy Control Sustainable Development (PCSD). Especially the term Pressure in PSR was changed into Driving Force in order to properly institute indexes, taking society, economy, and institute all into consideration.

DSPER structure adds Effect to the DPSR system. While index represents the present situation, model helps to predict the future and change direction. In the sustainable assessment model, comprehending the effect of environmental changes is necessary to predict changes in the future. In other words, to assess sustainability of a city, it is necessary to understand the effects on the urban environment but those on the global environment are also beginning to be discussed. Here again the analysis on the Effect as well as on the State of the present environmental situation is to make sure of policies which will reduce green house effect in the international level and to draw attention to climate change. Among DPSER Modules, this study contains Effect, in that it is necessary for modeling the assessment system and also in that effects should be grasped to predict future changes and to build policies for the changes.

However, the study can be inconsistent because effects can hardly be calculated, existent study is quite limited, a huge number of data are needed, and the methods are varied. Even though it has limitation of time, labor, and data, not only national but beyond national level, this study had to embrace Effect, since it is necessary to comprehend the effect in the assessment of city sustainability. As a result, instead of traditional assessment system which vertically discusses individual environmental elements like pollution, national environment, and agreeableness, this study centers around ecological aspects, that is the relationship between "inherited natural environment", and "human beings taking its advantage." In other words, it is based on the DSPER structure which here can represent human activities under the social economic background (Driving Force), environmental load from those activities (Pressure), environmental State these cause, and the Effect due to environmental changes, and Response from human beings (see Figure 2). Each factor contains

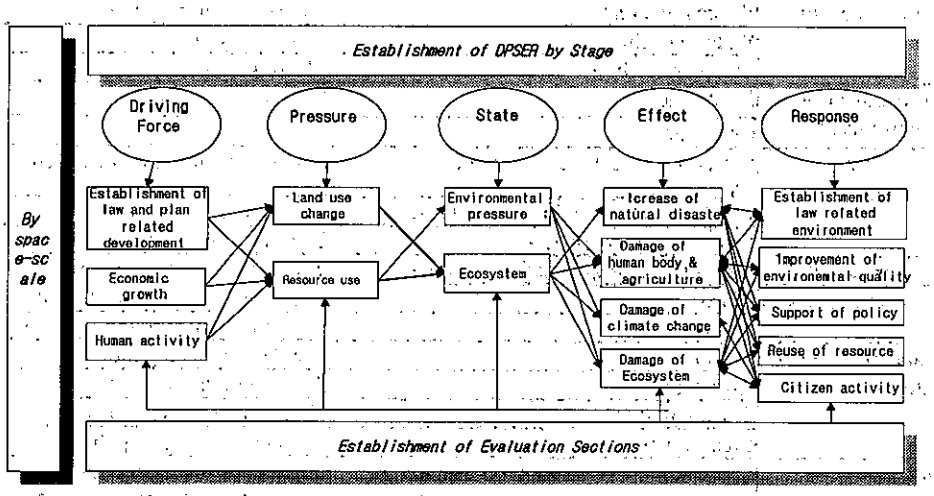
several indicators (see Table 1).

Figure 2. Development Framework of DPSER Module



As for the contents of the assessment sections, the driving force is related laws and plans, economic development, and human activities, all of which cause increasing use of energy and natural resources, and the change of land use. The environmental conditions are accordingly changed resulting in increased environmental load, deteriorated ecological system, and depleted natural resources. This changed environment and in return inflicts a blow on human life and ecosystem on the whole globe. As a result, it will naturally increase natural disasters. As a reaction we institute environment-related laws, provide support through policies and administration, and make efforts for better environmental quality and recycling (see Figure 3).

Figure 3. Relationship between assessment sections and their contents



Source: Institute of Global Environmental Strategies (2000), Urbanization, Industrialization and Sustainable Development in Korea –The Case of Study on Ulsan and Ansan Cities-, Korean IGES members (unpublished)

Table 1. Components of environmental indicators in study area

Category	Intermediate	Individual Indicators	Indicators
Driving Force	Human Activities	Population	Population Density
		Transportation	The Number of Automobile
	Policy and Finance	Socio-Economic Policy	Change of Socio-Economic Policy
		National Development Policy	Change of national development policy
		Land use policy	Land use change
		Industrial policy	Change of industrial policy
		Resource and energy policy	Change of Resource and energy policy
Pressure	Land use change	Urbanization rate	Urbanized area/ urban areas
		Land use change by category	Land use change by category
	Resource use	Amount of energy consumption	Amount of Gasoline and Petroleum
		Water resources use	Pipe line water
	Productivity	Manufactural products	Manufactural productivities
State	Ecosystem	Quantity	Green area in urban area
		Quality	Plants Density of plants
		Distribution	Isolation & Continuty
	Environmental Pressure	Air quality	NO_2
			SO_2
		Water Quality	BOD
		Rain (water)	Surface Water
		Ocean	Ocean pollution
		Hazard waste	Amount of Solid and hazard waste
		Global worm	CO_2
		Soil	Cu
			Pb
	Quality of Life	Amenity	Beautiful District
			History and Culture
	Awareness on environment	Citizen	Citizen's awareness on environment
		Government	Government's awareness on environment
Effect	Effect on human	Disease	Disease Causes
	Material Damage	Natural damage	Flooding
	Deterioration of living conditions	Deterioration of amenity	Districts
			History and Culture
	Damage on ecosystem	Load on environment	Extermination of wild amimals
	Climate change	Acid rain	Acid rain days/ raining day
Response	Resources recycling	Waste recycling	Rate of waste recycling
		Water recycling	Water recycling
		Energy recycling	Heating system
	Improvement of environment	Plant space	Green protection
		Green area	Park
	Environment management	Law, control and regulation on Environment	Environmental law and system
		Environment education and information	Environment education
		Environment organizations	Environmental officials
	Environmental Environmental facilities	Domestic environmental technology	Environmental technology
		Water	Pipe line water and waste water
		Solid waste	Waste treatment to the energy consumption
	Policy and planning on environment	Land use	Land use related policy
		Air quality	Clean air quality policy
		Transportation	Transportation related policy
		Clean water	Clean water related policy
	International cooperation	International cooperation on technology	International cooperation
		Exchange of technology	Environmental technology cooperation

3. The Application of DPSER to the Ulsan Metropolitan City

Ulsan is the seventh large city in Korea, which has about one million inhabitants with one thousand and fifty-five square kilometers of total area, and eighty seven point two percent of financial self-support rate. The fertile land was created across the Tae Hwa River, Ulsan. On-san and Bang-o-jin ports are connected with Ulsan Bay and the industrial site that is formed on the hilly districts covers around nineteen million Pyong (3.3 square meter) area where all of them became the foundation of the development of Ulsan as an industrial city (UMC, 1999).

The city of Ulsan is divided into new and old sections, and suburban area. And suburban area is divided into farming and fishing villages with a green belt. This city was a typical fishery village until 1960. However, the UMC is one of the fastest industrialized cities within the country or in the world since 1962 when she became a city[1]. She had become a symbolic city of Korean economic development in terms of industrialization, urbanization, and even environmental problems. The Korean government nominated Ulsan as a special industrial area and established an industrial center by the 'Special Law of National Industry Site Development' (Corporation of Industry Site Development, 1987) in 1962. Based upon this law, Ulsan National Industry Complexes were constructed.

At the initial stage of industry complex development, its population and size were respectively 85,000 and 176.04 km^2. However, its population and size are separately 991,000 and 1,055.55 km^2 in 1996. The number of population has increased about 12 times and urban size six times during 34 years. She also has grown to the seventh largest city and is well known to all over the nation and the world for its petrochemical and heavy industries and became one of the important nucleus cities in the Pacific Rim areas of the World (UMC, 1997). Especially, the development of UMC has been lined up with that of the heavy and chemical industrial complexes. Therefore, the UMC has experienced the serious environmental problems since the 1970s and paid attention on the improvement of urban environment. These concerns has contributed the improvement of urban environment and in a broad sense, urban environment improved since 1995.

Environment indicators are signposts that can point the way to sustainable development. While there is still no precise definition of sustainable development, environmental indicators can help to show whether we are moving in the right direction. Unifying economics and environment in decision-making may be the key to understanding how well we are navigating the course to sustainable development. To move to sustainable development, decision-makers need several information on environment indicators as follows: They need information about where they are at the moment and on developing trends and pressure points. They also need information about the impacts or effects of interventions or policies put into place. Moreover, they need feedback on which adjustments to make to speed up or slow down the effects of their interventions and about milestones achieved or about failures that frustrate progress.

Indicators are useful because they point to trends and relationships in a concise way. They provide

[1] A city is a town where more than 50 thousand peoples live.

meaning beyond the attributes directly associated with them. In this sense, they are different from primary data or statistics, providing a bridge between detailed data and interpreted information. Indicators have been used for many years and are common in planning and economics where indicators such as GDP, the unemployment rate, the literacy rate and the population growth rate are widely monitored. Indicators can be used for many purposes such as measuring progress towards pre-established targets and goals or simply getting a picture of where things stand at a particular point in time. They can contribute to guide national policies and to facilitate national reporting on measures sustainable development (http://www.un.org/esa/sustdev/indi6.htm).

3.1 Driving Force of the UMC

3.1.1 Urban Population Growth in UMC

The population of UMC had increased about five times from 1962 to 1997. Population density also increased around five times during the same period. However, the number of households had increased about ten times during the above period (see Table 2).

Table 2. The Change of Population and Area in Ulsan

Year	Total Population	Increasing Rate (%)	Population Density	No. of Households	Area (㎢)
1962	211235	1.0	209.5	32238	1008.32
1965	222965	1.0	221.1	38123	1008.32
1968	249131	2.1	247.1	44916	1008.32
1972	275355	5.9	274.2	53704	1004.22
1975	368612	4.6	366.0	76738	1007.18
1978	482150	4.3	476.6	99930	1011.58
1982	593042	4.5	585.5	130964	1012.82
1985	670358	1.0	638.4	163443	1050.08
1988	743184	3.9	705.8	184974	1050.92
1992	898630	5.1	854.4	262970	1051.81
1995	969196	2.4	918.4	289295	1055.35
1997	1013070	2.0	959.6	309945	1055.70

Sources: Department of Information Management in the UMC

It means that the UMC had processed the urbanization for that period like other cities. Rural populations had migrated to the UMC to get jobs. The UMC provided lots of job opportunities because two national industrial and several local industrial complexes were established in that city. The increasing rate of population in the UMC was shown high from 1972 to 1982 when the economic effects of industrial complexes were presented. The total number of cars increased around 13 times during 13 years from 20,373 in 1986 to 262,294 in 1997. Automobiles increased about 25 times for the same period. Especially, the numbers of trucks for the delivery of industrial products increased around 36 times for the same period The acute increase of number of cars created several environmental problems such air pollution, noise, and car accident (see Table 3).

Table 3. The Number of Cars of UMC

Year	Total	Automobiles	Trucks	Buses	Special Cars
1986	20376	8896	8510	2091	879
1987	26803	12204	10567	3040	992
1988	37275	18878	12770	4521	1106
1989	53002	30335	16112	6115	440
1990	70877	43097	19443	7775	562
1991	94515	62540	22303	8835	837
1992	119357	82446	25230	10006	1675
1993	144705	104078	28375	10612	1640
1994	174642	132598	28727	11630	1688
1995	209803	160752	35303	12054	1694
1996	241600	188845	38141	13038	1576
1997	262394	207053	39938	14053	1350

Source: Department of Information Management in the UMC

3.1.2 Development Process of Industrial Complexes in the UMC

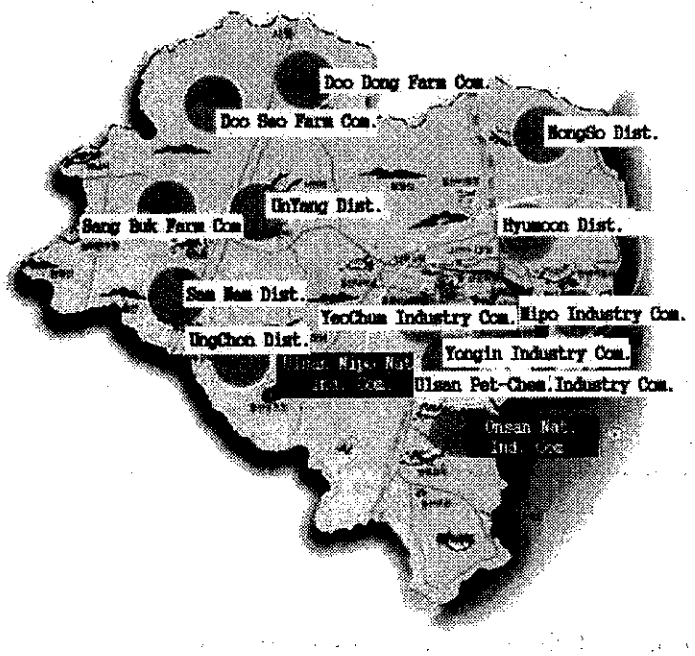
The city's growth is directly related to the development of industrial complexes because the central government utilized the Ulsan industrial complexes as an engine of the Korean economic growth. The stages of development of industrial complexes are as follows: the Port of Ulsan was originally called "Yeomp'o", one of the major harbors in old Korean, which were opened for the foreign trade in

1426 in the era of the King Sejong of Lee Dynasty. In 1963, it became the first industrial port in support of the economic growth of Korea. Following the major construction of wharves in 1966, Onsan and Mipo Port were added to the boundary of Port of Ulsan in 1976, to facilitate the port development in the region.

The first stage (1962-1966) focused on the building of an industry site and infrastructure such as port, road, and water provisions for the industrial complexes. The second stage (1967-1971) made an effort to construct the heavy and chemical industrial complex. A refined oil industry along with chemical fertilizer industries was built in the waterfront areas such as Jangsengpo and Yeochun. In order to support these facilities, such infrastructures as port, road, and power plant were provided in this era.

The third period (1972-1976) was a leaping stage in the development of Ulsan industry. Ulsan's representative industries such as automobile and shipbuilding were constructed in Yumpo and Mipo industry complexes during this period. In the fourth stage (1977-1981), agglomeration and scale effects of these industries was gradually generated and several industries such as iron, automobile, and lumber were located in order to enjoy these side effects. An industry belt was established in the fifth period (1982-1986) because existing industry complexes were continuously grown in terms of productivity and scale, and new industry complexes like Unyang and Yongyun were built.

Figure.4. Locations of Ulsan Industry Complexes



And then Ulsan has grown the biggest heavy-chemical industry complex city in South Korea in terms of amount of products and scale. In another aspect, Ulsan has tried to reduce environmental problems through changing the structure of industrial base from petroleum chemical plants to automobile and

shipbuilding plants, which are relatively a low pollution industry. Eventually, main industries gradually has changed from the petroleum chemical industry to the automobile and shipbuilding since 1987 (UMC, 1997). As a result, two national industrial complexes and several local industrial complexes were located in UMC as the Figure 4. The productivity is corresponded to 18.9 percent in that of nationwide manufacturers and 21.1 percent in amount of nationwide export customs (UMC, 1997). Finally, Ulsan was eventually grown to the symbol of Korean economic development.

3.2 Environmental Pressure in the UMC

Environmental pressure indicators represent the pressure on the environment that affects sustainable development. As the above description, the environmental pressure of the UMC was initially begun by the central government in order to promote the economic growth through the building of heavy-chemical industry complexes but their results were shown in the local area. Two main components of environmental pressures are the increase of GDP and energy consumption. Figure shows the growth pattern of GDP and energy consumption since 1971. Both factors has maintained 5-10 percent growth rate during the same periods. These have contributed to deteriorate the environmental problems of the UMC and Korea. Environmental Pressures in UMC are summarized at Table 4-8. Urban areas, urbanization rate, land use change, the increase of oil consumption, the change of industrial structure effect on the local environmental pressures. Especially, oil consumption increased three times for 5 years from 1992 to 1997. Furthermore, three industrial complexes were established in 1997. Local government tried to promote the local economy after the introduction of local autonomy.

Table 4. The Urban Population Growth of the 7 Largest Cities in Korea

	Total Pop.	Urban Planning Area		Administration Area		Urbanization Rate(%)	
		Urban Pop.	Non-Urban Pop.	Urban Pop.	Rural Pop.	Urban Planning Area	Administration Area
	(A)	(B)	(C=A-B)	(D)	(E=A-D)	(B/A*100)	(D/A*100)
Seoul	10,389	10,389	-	10,389	-	100.0	100.0
Pusan	3,865	3,865	-	3,840	25	100.0	99.4
Taegu	2,502	2,534	-32	2,483	19	101.3	99.2
Inchon	2,446	2,403	43	2,378	68	98.2	97.2
Kwangju	1,324	1,340	-16	1,324	-	101.2	100.0
Taejun	1,323	1,329	-5	1,323	-	100.5	100.0
Ulsan	1,013	898	115	910	103	88.6	89.8

Table 5. Land Use by Land Category in UMC

(Unit: m^2)

Year	Residential Land	Industrial Site	School Site	Road	Rail Site	Mineral Spring
1992	17,038,608.9	20,904,979.8	1,759,584.6	10,136,320.6	1,127,808.9	
1993	17,728,857.9	22,157,958.5	1,828,071.7	10,666,393.7	970,257.0	
1994	18,693,527.3	22,538,706.5	1,885,437.2	11,189,996.5	981,885.4	
1995	32,407,211.8	34,211,758.0	2,589,016.2	27,883,555.2	1,907,667.1	6.0
1996	33,053,219.3	36,023,164.7	2,646,916.2	28,153,278.1	1,919,436.1	6.0
1997	34,287,932.7	38,205,124.0	2,668,356.5	28,545,551.1	1,918,853.1	6.0

Table 6. Oil Consumption in the UMC

	Distillate Oil (ton)				Bunker C (ton)		
	Total	Gasoline	Kerosene	Fuel Oil	Heavy Oil	Oil	Others
1992	327,434	80,093	39,745	207,596	-	-	-
1993	349,350	96,881	42,665	209,804	-	-	-
1994	392,088	121,658	41,135	229,295	-	-	-
1995	447,623	147,920	41,852	257,851	-	-	-
1996	785,101	257,805	86,874	440,422	-	-	-
1997	927,593	265,344	203,503	458,746	-	-	

Source: Department of Regional Economics of the UMC in 1997

Table 7. Status of Mining and Manufacturing in the UMC

	No. of Establishments	Monthly Average No. of Workers	Wage & Salary (million won)	Gross Output (million won)
1992	359	104,685	1,642,011	20,751,803
1993	606	116,981	1,931,132	23,298,222
1994	578	117,449	2,301,767	26,941,919
1995	978	145,139	3,084,911	41,658,414
1996	1,017	144,886	3,445,551	45,537,812
1997	1,004	138,217	3,165,397	53,297,019

Source: Department of Regional Economics of the UMC in 1997

Table 8. Industry, Agriculture and Industry Complexes in the UMC

	Number of Complex	Total Area	Number of Establishments	Number of Workers
1992	2	261	13	1,200
1993	2	261	17	1,744
1994	2	261	20	1,950
1995	3	332	22	2,176
1996	3	332	27	2,223
1997	6	71,335.2	583	114,944
Ulsan·Mipo Industrial Complex	1	46,222	421	102,437
Onsan Industrial Complex	1	24,518	135	10,184
Songbuk Agro-industrial Complex	1	138.5	9	1,189
Tuso Agro-industrial Complex	1	122.6	14	850
Tudong Agro-industrial Complex	1	69.7	4	284
Dalchon Agro-industrial Complex	1	264.4	n.a.	n.a.

3.3 Environment States of the UMC

These explosive urbanization and industrialization however created several environmental problems such air quality, sewage water, soil, and river and ocean pollution in UMA. Especially, Ulsan's environmental problems are more serious than those of any other city because the manufacturing plants in the city are mostly related to heavy and chemical industries. At the initial stage of development of industry complex, there was no consideration on its environmental impacts (Department of Environmental Protection of UMC, 1998).

Table 9. Source Industries of Environmental Pollution in 1998

Number of Source Industries									
Sub Total	Air	Water	Noise	Specified Waste Materials	Dust	Bad Smell	Poison	Soil	Automobiles
2,018 (616)	770 (330)	791 (286)	209	248	289	35	170 (122)	448	262,394

Source: This data is provided by the Department of Environmental Protection in UMC in 1998.
* ( ) is the number of source industry of two national industry complexes (Ulsan and Onsan).

Moreover, the characteristics of environmental problems are that its impacts slowly show up and last for the long time. Heavy chemical industry complexes were usually constructed in the 1960s but environmental problems actually were generated in the 1980s. Moreover most industrial complexes were located in the water front area. This resulted in the pollution of river and coastal water.

Detrimental smog of manufacturing plants moved to the residential area from the spring to the fall, following the direction of the southeast wind (see Figure 4). More specifically, source industries of environmental pollution are like Table 9.

As the Table 10, one-third (616) of total pollutant factories (2,018) is located in two national industry complexes. Main pollutants of national complexes are air and poison pollution because major factories in these areas are petroleum chemical or heavy industries. More specifically, two major environmental problems in the UMC are air quality and water pollution.

3.3.1 Air Pollution

Air pollution in UMC had been very serious because most of industrial complexes were related with heavy-chemical industries like Figure 4.

Table 10. Air Pollution (SO_2) by the Metropolitan City

(unit: ppm)

	Standard	1993	1994	1995	1996	1997
Seoul	0.03	0.023	0.019	0.017	0.013	0.011
Pusan	0.03	0.028	0.023	0.023	0.022	0.018
Taegu	0.03	0.035	0.038	0.031	0.023	0.016
Inchon	0.03	0.021	0.022	0.023	0.012	0.013
Kyongju	0.03	0.014	0.013	0.010	0.008	0.009
Taejun	0.03	0.020	0.021	0.017	0.015	0.011
Ulsan	0.03	0.032	0.030	0.028	0.022	0.019

Table 11. The Circumstance of Air Pollution in UMC

	Unit	Standard	Average Levels of Air Pollution by Year							
			1991	1992	1993	1994	1995	1996	1997	1998
SO_2	PPM/Y	0.03	0.038	0.031	0.032	0.031	0.028	0.022	0.018	0.016
TSP	$\mu g/m_3/Y$	150	96	95	97	95	98	106	75	69
O_3	PPM/8h	0.06	0.013	0.012	0.014	0.013	0.015	0.015	0.015	0.017
NO_2	PPM/Y	0.05	0.022	0.027	0.028	0.026	0.023	0.023	0.023	0.022
CO	PPM/8h	9	1.7	1.3	1.4	1.2	1.3	1.0	0.9	0.8
Acid Rain	P.H	5.6	5.5	5.7	5.3	5.4	5.4	5.6	5.7	5.9

Source: Department of Environmental Protection in the UMC (1998.5), Circumstances of Environmental Preservation in the UMC.

Eventually, UMC was one of most polluted cities in Korea. It resulted in the serious environmental damages. Civilians who lived in the outskirts of industrial complexes were relocated to other places (see environmental effect section).

However, central and local government had made an effort to change local industrial structure from heavy chemical industrial industries to automobile or high tech-oriented ones. Due to these efforts and civilian awareness on the environments, air quality has been gradually improved in 1990s.

3.3.2 Water Pollution

The most serious environmental problem in Ulsan is water pollution. The quality of drinking water or pipeline water is not good because the lake for the pipeline water is polluted. Moreover, the volume of water which people use has been continuously increased. In terms of water problems, Ulsan met two problems. One is a shortage of total water volume and another is a low quality of water.

Table 12 The Generation of Wastewater, 1993-1997

	Unit	1993	1994	1995	1996	1997
Household Wastewater	1 Thousand ㎥/ Day	13972	15976			
Per Capita	ℓ /Person, Day	314				
Industrial Wastewater	1 Thousand ㎥/ Day	6412	7259	8741	8926	4874
Discharge Amount	1 Thousand ㎥/ Day	2093	2316	2375	2511	2618
Livestock Wastewater	1 Thousand ㎥/ Day	170138	175669	168370	197017	199917
BOD Discharge	1 Thousand ㎥/ Day	470	403	455	541	547

Source: National Statistics Organization

Table 13. Water Pollution in the UMC

			Average Levels of Water Quality by Year(ppm)							
			1991	1992	1993	1994	1995	1996	1997	1998.4
Taewha River	Upper	BOD 1	1.2	1.2	1.2	1.5	1.5	1.8	1.3	2.0
	Lower	BOD 3	11.7	6.4	6.9	9.7	9.8	11.3	10.7	7.4
HeiYa River		BOD 3	6.6	3.5	3.3	4.2	3.8	2.8	3.5	2.5
Coastal Water		COD 4	2.0	1.7	1.3	1.9	1.9	1.3	1.3	-

Source: Department of Environmental Protection in UMC (1998.5), Circumstance of Environmental Preservation in UMC.

Water pollution exceeds the environmental criteria in most areas except coastal water. In other words, the UMC is experiencing serious water pollution (Table 13). However, water quality has improved

since the middle of the 1990s due to the same reason why accounts for the improvement of air quality. Other environmental problems such as noise, soil, and poison also became better as the result of the effort of the local government and the public (UMC, 1997). In a broad sense, the environmental quality of the UMC has been improved but that of specific industrial complexes is still deteriorating.

3.3.3 Waste Generation

Solid wastes are composed of household and industrial wastes. Since the 1960s, when the industrial complexes were established, wastes from both household and industry have been continuously increased. However, due to the volume based-collection policy and recycling policy, the generation of household waste has recently decreased in terms of total amount and daily amounts per capita.

Industrial waste has been decreased since 1995 as local autonomy was adopted. Local government made an effort to reduce the generation of industrial waste. Before the local autonomy, central government did not pay much attention to reduce the local waste. Moreover, people concerns on the qualities of environment and life because the UMC is one of the most polluted cities in Korea. Efforts of the local government and citizens resulted in the reduction of both household and industrial wastes from the mid-1990s.

Figure 5. Household waste generation in the UMC

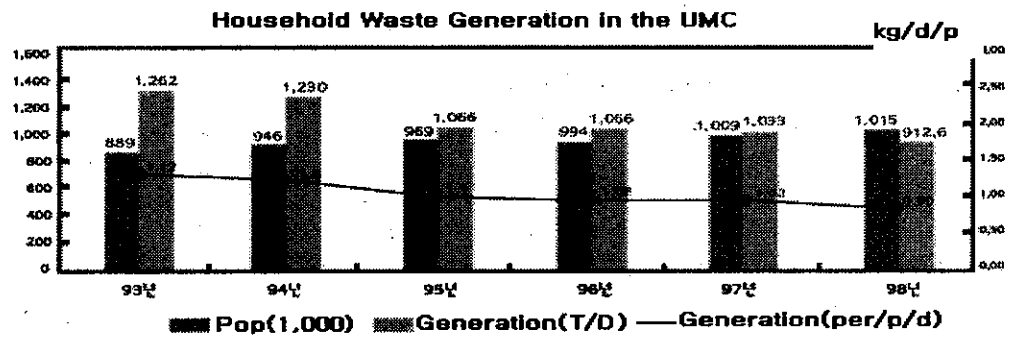
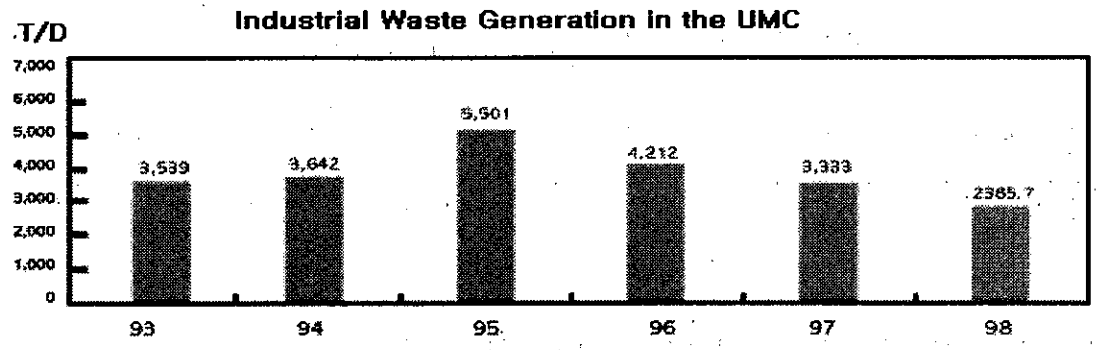


Figure 6. Industrial waste generation in the UMC



3.4 The Environmental Effects on UMC

Since 1962, when the First Five Years Economic Development Plan was established, a top priority of government policy has been a focus on development-oriented economic growth to escape from absolute poverty. This policy eventually brought material affluence. However, the environment problems became serious from the middle of the 1980s. Particularly, the environmental problems of heavy industry cities like Ulsan and Ansan have become serious social issues. The central government opened an Environment Administration Agency (EA) in 1980 in order to consider the environmental problems.

It surveyed the environmental damage caused by Ulsan and Onsan national industry complexes in 1984. Based upon the results of this survey, the government compensated citizens influenced by the environmental damage and made a plan to force them to move to other areas (Kim and Hong, 1997). Total numbers of households that had to be relocated were 8,138 and relocations are still not completed due to an insufficient budget (Department of Environmental Protection of UMC, 1998).

Moreover, the relocation also must be implemented continuously because the spatial range of the environmental damage becomes larger. The central government designated the Ulsan industry complexes as a special management district of air quality in 1986. In spite of these governmental efforts, the environmental problems of other large cities including Seoul continuously worsen.

3.5 The Environmental Response in the Ulsan Metropolitan City

The UMC government like other local governments has implemented the environmental policies of central government since 1961. However, after the local autonomy in 1995, the role of local government has increased in the local environmental governance. In order to challenge the national environmental problems, the Ministry of Environment was opened in 1994.

In the local government level, Ulsan opened the department of environmental management in 1987. Local government approached more positively these environmental problems because they are directly related with the quality of life for citizens. At first, the local government employed a monitoring system to note the circumstances of the pollution on air and water, smoke, noise, poison, coastal water, and so on.

Based upon the survey on the environmental pollution, she made a mid-term implementation plan for the environment improvement in 1997. Especially, this plan focused on the improvement of quality of life for the Ulsan citizens but the environmental policies of central government mainly emphasized the compensation to the damaged citizens and their relocations to the other place.

The basic principle of this plan is that the emission of pollutants should be "Zero Base." Based upon this principle, the local government controls the environmental pollution as follows: 1) In order to construct a new factory, it must produce the environment-friendly goods or recycle the waste. 2) In order to increase the scale of existing factory, total amount of pollutant emission should be less than that of the existing plant. Following an officer of Ulsan, he argues that if this plan is implemented

successfully, Ulsan will be changed from the symbol of polluted city to a clean city environmentally in 2002.

3.5.1 Economic Instruments for the Environmental Response

Following the national guideline on the environmental responses, based upon the "Green Ulsan 21," the UMC has adopted the following instruments to save the local environments. Firstly, the Emission Charge System was put into effect in 1983, in order to prevent damage to the environment due to pollutants discharged in excess of the specified emission standards and to ensure that firms would actually observe the permissible limits. If permit holders are caught violating the conditions of their permits, the system imposes charges on the emissions or discharges of certain pollutants that are in excess of emission limits.[2] The emission charge system was modified in 1997 to include volume or discharge based charge (the Basic Emission Charge[3]).

Secondly, the Deposit-Refund System for Waste Disposal went into effect in 1992. To promote recycling, the MOE has the authority to collect deposits from producers and importers of easily retrievable and recyclable products. When pollution is avoided or reduced by returning the products or their residuals, a refund follows. In 1999, twelve items among six products, including beverage containers, tires, the lubricating oil, are liable to the deposit-refund system.

Thirdly, the Waste Treatment Charge System was introduced in 1993 to promote waste reduction and resource conservation. This system charges producers or importers of 29 items of 10 products which use materials and containers that contain harmful substances or that are difficult to collect or recycle.

Fourthly, the Environmental Improvement Charge was levied on the owners of commercial buildings and on diesel-powered vehicles in order to curb increasing pollution from commercial and consumption sectors and in order to raise funds for environmental investment. The major objectives of the charge are to foster pollution reduction and to secure funds for environmental investment. The rate of charge for commercial buildings is on the amount of fuel and water used, and that for diesel-powered vehicles is on the age of the vehicle and the estimated volume of exhaust.

Fifthly, the Volume-Based Collection Fee System for Domestic Wastes went into effect in 1995. Its objectives include reducing the volume of domestic wastes generated by households and promoting recycling by imposing collection fees according to the volume of wastes generated.

To efficiently promote the financial investment on the environmental improvement and secure new revenue sources, the government introduced the Special Account for Environmental Improvement in January 1995. Financial resources secured through economic instruments are deposited in the

[2] Ten air pollutants, including SOx and TSP, and seventeen water pollutants, including BOD, COD, and suspended solids, are subject to the charge.

[3] The change occurs in parallel with modifications to the permit system; emission and discharge permits stipulate an upper limit for the amount of pollutants that can be emitted. The emission charge will then become payable on all discharges and emissions in excess of 30 percent of this maximum amount, thus creating an incentive to permit holders to reduce emissions to below 30 percent of the maximum allowed.

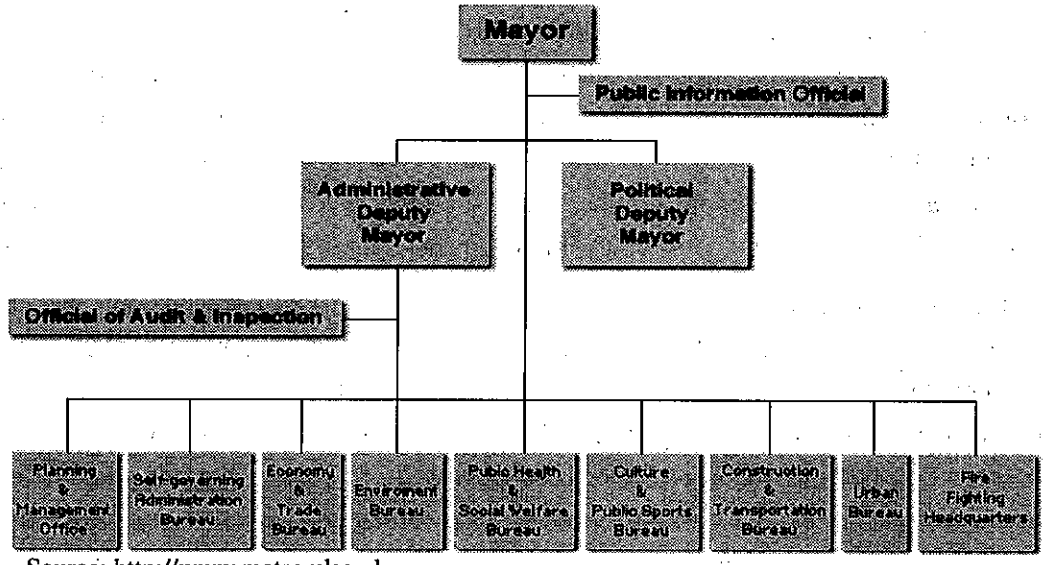
Environmental Improvement Special Account to pay for the construction of basic environmental facilities, such as sewage treatment plants and waste treatment facilities. Revenue sources include various charges imposed on polluters, transfers from general and other accounts, loans from the National Bond Management Fund and foreign loans (MOE, 1997 and 1999).

In 1996, the central government adopted a National Action Plan for Agenda 21. Moreover, the MOE is also responsible for the policies relating to Environmental Impact Assessments (EIA). In order to ensure the objectivity of the EIA, Central and Regional Committees for EIA, which consist of professors, engineers, and specialists, review the assessment. Residents are invited to the hearing process of EIA. Those who plan to carry out projects that are subject to EIA must prepare draft assessments, which are made public, and hold a public hearing on the proposed project (MOE, 1997; Jeong and Cheong, 2000).

3.5.2 Political and Administrative Organizations in Ulsan Metropolitan City

As the above description the right and responsibility of local government on the environmental governance have been significantly increased after the local autonomy. And then UMC government enlarged the organization and the number of officers on the environmental governance since 1995. Basically, UMC is composed of 7 bureau, 2 offices, 1 headquarters, and local assembly. Each community has its own administrative organization. Moreover, the citizens elect a mayor and local assembly. And then they have to consider local environmental problems which local citizens have been concerned.

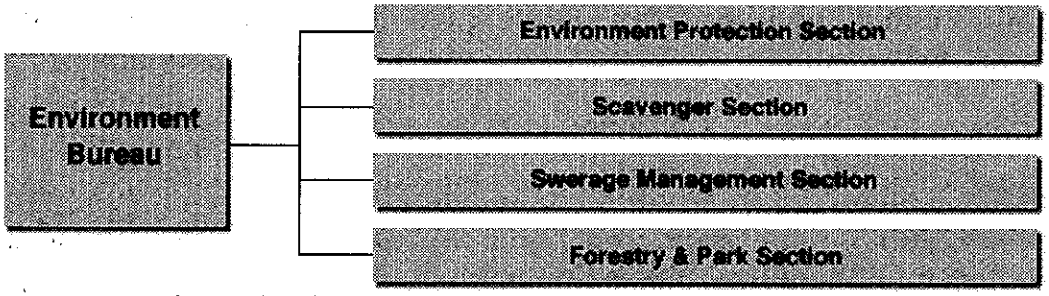
Figure 7. The Organization of Administrative Structure in Ulsan Metropolitan City



Source: http://www.metro.ulsan.kr

Environment Bureau is composed of three sections. Environment Protection Section covers the environmental policy, water quality management, and air quality Management. Scavenger Section charges scavenger administration. Sewerage Management Section takes the work on the waterworks management, sewerage administration, and sewerage facilities. Forestry & Park Section had a responsibility on the management of green tract of land and administration of park & forestry. In addition, there are several environment-related organizations that are belonged to other sections.

Figure 8. The Environmental Section of Ulsan Administrative Organization



Source: http://www.metro.ulsan.kr

3.5.3 The Decision-Making Processes for the Environmental Response

Actually urban environmental problems are closely related with the local people's thinking and activity because the lives of local people as both consumers and producers of infrastructure services influence the nature, quality and flow of environmental infrastructure. Therefore, they have to be actively involved throughout the project cycle from the formulation of goals and policies to its implementation. There often are conflicts between the policy preferences of different sectors of society (Mangal, 1998). For example, industries benefit from lax water standards but they externalize the burden to downstream populations who are likely to want stricter standards. Local community and citizens facet the environmental problems due to lax pollution standards but industrial sectors can benefit from them. However, the industrial sectors also can face the environmental problems in the long terms. Because of these conflicts, all stakeholders participate in formulating the environmental policy or suggest their opinions to the policy building in order to ensure that the goals of environmental governance are consistent with the broader values and goals of society as a whole.

Since the adoption of local autonomy, the UMC made the municipal codes on the principles of environmental preservation and the role and duty of local government, industry, and citizens in 1997. Based upon this code, eventually Ulsan Metropolitan City established the Mid-term plan on the UMC environmental improvement (1998-2002) in 1997. It is actually the first comprehensive plan for the improvement of local environment. Before this plan, the local government only had implemented the environmental plan of central government. This plan contained 10 sections and 103 projects on the environmental management, the preservation of natural resources, air and water quality, and pipeline

water (http://www.metro.ulsan.kr).

Furthermore, in order to promote the citizen's participation in building the environmental policies, Environmental Committee, Environmental Preservation Consulting Committee, and Environmental Conflict Coordinating Committee were established in 1997. The first covers the environmental education for the public and consulting on the environmental policies and alternatives. The second consults the environmental preservation and environmental plan. The third charges the consulting of environmental conflicts among agents and between the public and the private sectors. All committee are composed of governmental officers, professors, and NGO groups. The UMC also established the "Green Ulsan 21 Promotion Committee in order to implement efficiently the "Green Ulsan 21 Plan." Its members are composed of the education, broadcasting, police, NGOs, and citizen organizations (http://www.metro.ulsan.kr).

3.5.4 Environmental Responses of NGOs

Due to the increased public awareness of environmental preservation, environmental NGOs have been more active in their activities. Environmental NGOs are engaged in diverse activities, such as keeping up public relations on environmental preservation, conducting campaigns, surveys and research on environmental issues, and holding seminars on environmental policies. Moreover, most of NGOs have their own local branches. Therefore, the roles of NGO in central government are similar with those of local government. The roles and activities of the NGOs are as follows:

First, the Korea Environmental Preservation Association and the Toxic Chemical Management Association were established in accordance with the Basic Environmental Policy Act and other relevant laws. The Associations were formed to conduct inspections and research, develop environment-related technology, promote education and training, and improve public relations.

Second, organizations that are similar to research institutes include the Korea Action Federation for the Environment, the Baedal Eco-Society, the Environment & Pollution Research Group, etc. These organizations, consisting of environmental experts and social leaders, hold seminars, conduct academic studies and research on environmental policies, and exchange environmental information with both national and international organizations.

Third, with the environmental movement developing into a kind of civic movement, various civic groups, including religious groups and women's groups, are staging campaigns for environmental preservation under diverse themes. For example, campaign titles such as "Let's reduce food wastes," "Let's use public transportation," and "Let's save water," have become common slogans for many environmental groups. On February 1, 1996, representatives from six major religious groups met together to declare the "Declaration of the Greening of Our Society" and to start an aggressive campaign for environmental preservation.

Fourth, there are many regional organizations represented by local residents, such as Earth and Eco-friends. These organizations are involved in the environmental preservation of the local community.

They hold seminars on local environmental issues and conduct activities to protect water supply resources.

Actually 10 NGOs are currently participating in the local environment improvements such as the public awareness, environment watch, and preservation of eco-system. The Green Environment Conservation, the Korea Environment Movement Federation, and some other NGOs are Ulsan Branches of national-wide organization. Onsan Complex Environment Management Committee, Community Countermeasure Committee on Onsan Pollution Problems, Taewha River Conservation Committee, and some other NGOs are working for the local specific environmental problems. The Ulsan Natural Environment Preservation Committee, Onsan Environment Preservation, and Environment Preservation Committee of Ulsan Local Prosecution Attorney are on action for the local natural environment and eco-system. Total 80 plants and more than 3000 personals including university, government officers, and professionals are participated in the above NGOs' activities (http://www.metro.ulsan.kr). In fact, 9 factories are certified as the "Environmentally Friendly Plants" in the UMC. Local government supports these factories with the financial, technical, and other incentives (http://www.metro.ulsan.kr).

3.5.5 Public and Private Partnership for the Environmental Responses

Local environmental problems are closely related with the local people's lifestyle, awareness, and participation. Therefore, the success and failure of environmental governance are highly depended upon the public and private partnership on the local environmental issues. As the above descriptions, UMC environmental problems are significantly different from those of other cities. Especially, UMC was the origin of the Korean urban environmental problems because where was the heavy-chemical industry-oriented city. Therefore, the concern on environmental governance in UMC is higher than any other city in Korea. The "Campaign-Oriented Culture", which is probably a result of military dictatorship culture, encourages the partnership between the public and private sectors. There are several environmental governance activities by the public-private partnership.

First, the Green Ulsan 21 will be developed into the citizen movement on the environmental preservation. This program has its own community organizations for stimulating the citizen participation in the Green Ulsan Network. It charges the citizen education and public awareness on the environment preservation.

Second, the Environmental Technology Development Institute was established in 1998. The Ministry of Environment, local municipal, Ulsan University, Industry, and citizen including NGOs were involved in this program. This institute charges the environmental technology development, survey on the natural resources and environmental pollution, and water quality management system. Its total budget was 1.35 billion Korean Won. Its budget came from 50% in central government and 50% in local government.

Third, in order to improve the local environmental quality, local environmental standards will be

reestablished in the near future. This project is on processing. A new standard will be higher than that of central government (SO_2: 0.030 PPM/year; TSP, 150㎍/㎥/year) and World Health Organization (SO_2: 0.015~0.023 PPM/year; TSP, 60㎍/㎥/year).

Fourth, the Ulsan Health and Environment Institute is establishing in order to study the relationship between the public health and environmental problems. It will be opened in July 2000. In addition, several environmental governance programs are implementing and are scheduled. As the above description, the effects of these environmental governance programs, however, are not clear or very small because most of programs were established very recently or are at the beginning stage now. In spite of these problems, the public concerns on the environmental governance, including housewives, have been largely increased due to the implementation of local autonomy and NGO's activities. Moreover, the central and local governments also begin to recognize the importance of the local environmental governance. Therefore, we can have the optimistic view on the improvement of Ulsan environmental problems.

4. Policy Implications for Urban Environmental Management in Ulsan

The rapid economic growth, urbanization, and industrialization impose the growing demands on air, water, and land resources in East Asia. The region, particularly major urban areas, is plagued with higher level of air and water pollution. Land degradation and deforestation are widely witnessed in the region. Meanwhile, the public concern on a clean environment is graduaally growing along with rising income levels. Facing such environmental challenges, East Asian countries must prepare a new paradigm on the economic development strategy. A new policy approach is clearly needed in order to handle the global environmental issues and challenges posed by rapid changes in social structure. The government must accordingly develop environmental technologies to match those of industrialized countries, take immediate action to cope with environmental problems, and take an initiative in solving global environmental problems. An environmentally friendly consumption patterns and business management system must be fostered. The ideal of "Environmentally Sound and Sustainable Development (ESSD)" for the economic growth must be promoted. All these challenges make environmental governance system in Korea and especially UMC much more sophisticated. However these does not mean that the environmental governance system in UMC is very effective to meet the sustainable development requirement. There are several tasks and strategies to improve efficacy of the environmental governance system. Based upon the DPSER assessment model on the Ulsan Metropolitan City, this paper summarizes the conclusion for the sustainable development. Firstly, the administrative paradigm in the progressive era should be replaced by "governance" paradigm, especially environmental governance for the sustainable development. Based on this new paradigm, key themes of administrative reform should be to reduce organizational hierarchy, empower local communities, promote task-centered management, and apply multi-media approaches including the public-private partnership and citizen participation.

Secondly, local governments need to build up expertise in implementing and enforcing environmental protection measures to tackle compliance problems involving small local factories and enterprises.

Policy measures currently discussed to improve the capacity of local governments include the privatization of environmental service provisions, promotion of citizens' participation (of course NGOs) in environmental management, and development of Local Agenda 21 and comprehensive regional environmental plans, community partnership with industries, etc.

Thirdly, restoration and fortification of environmental capacity is needed. It is a prerequisite to have a margin within the limits of environmental capacity to continue economic growth without, however, compromising environmental quality. Furthermore, investment should be enlarged for fortification of sewage treatment plants, solid waste treatment installations, fostering environmental industries, and technology development for environmental improvement. Land use planning and industrial policy should maintain harmony with environmental policy.

Fourthly, it is urgent to develop new methods to solve and reduce regional conflicts. Some scholars suggest that the Polluter Pays Principle must be emphasized more. Others believe that the Beneficiary Pays Principle should be adopted as a way of settling regional disputes. Still others recommend the use of a community fee system regarding NIMBY facilities. However, the most important thing is to design a "principled negotiation" mechanism to solve growing environmental conflicts and disputes.

Fifthly, the promotion of public participation is encouraged. Environmental policy cannot be successfully implemented without the cooperation of the public. Recognizing these facts, the role of NGOs is becoming more important in Korea and increasing number of NGO leaders actually participate environmental policy formulation and implementation. Moreover, environmental education for students and the provision of suitable environmental information for the general public should be strengthened and enhanced to promote public participation.

Sixthly, to help promote voluntary environmental management and clean technology development, government should provide more flexible environmental regulatory system. Industries, which had paid little attention to voluntary environmental management, began to realize the importance of environmental management to survive in the high competition system of the global economy. Therefore, it is necessary to develop much more voluntary programs to help such positive business's attitudes. Moreover, it will be helpful to improve industrial environmental practices, if Korea can introduce the environmental accounting system for individual industry and bank loan system based on industries' environmental performance.

The developing countries must consider the environmental issues and their governance when they establish economic development strategies, considering the Korean environmental governance experiences. They must induce low-pollutant factories. Moreover, in order to solve local environmental problems, each local government must make a plan on the protection of urban environments and implement it, considering socio-economic situations of planned areas. Her citizens and organizations also must voluntarily participate in protecting urban environments. If other Asian developing countries obtain lessons from the Korean experiences, they can get away from the Korean terrible experiences and a sustainable economic growth can be maintained. They also can save the East Asian and global environments.

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Sustainable Development and DPSER Model: The Case of Ansan City

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1. Urban Environment in Ansan

A city is an organism with diverse structures and functions and grows while forming a system through continuous interactions of its constituents. Therefore, all issues involving cities including urban environment problems should be approached with a systematic, circular, and continuous concept. Until recently, however, they were mostly addressed in a fragmented and individual manner.

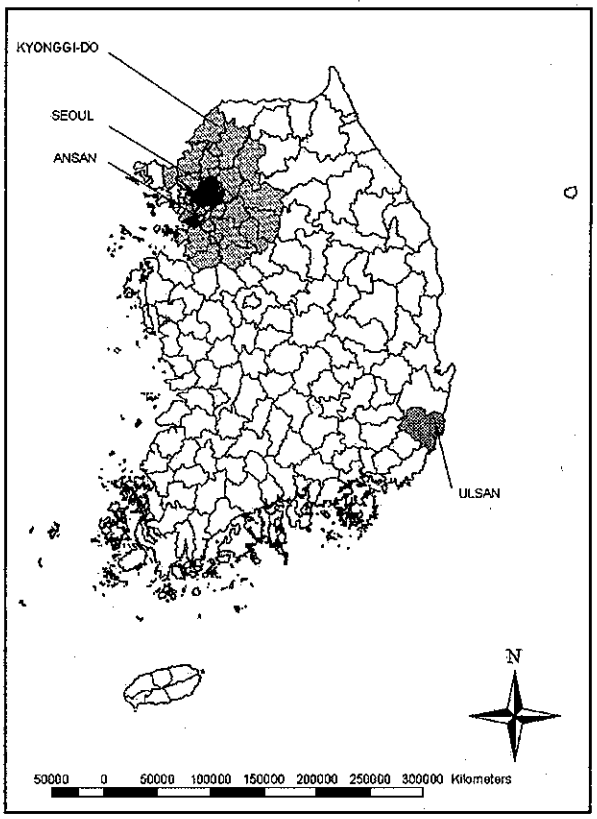
Especially, Some East Asia countries have accomplished an industrialization-led economic development. Such a rapid growth resulted in the sharp increase of consumption in both resources and energy. As a result, the impact of economic growth on natural environment became more serious than other regions. If the current development pattern continues, environmental load in this area is highly likely to increase sharply due to population increase and urbanization. In this regard, a need for an accurate urban environmental assessment model should be prioritized.

In order to realize the concept of sustainable development as a move of reflecting such practice, sustainability of city has emerged as one of the biggest issues in many cities and governments. However, there is still lack of discussions on what should be evaluated and how it should be evaluated in order to make a city sustainable. As a result, there are limitations in understanding the present state of a city in a sustainability aspect and the environment improvement efforts or policy benefits.

Accordingly, the objective of this study are to develop a model evaluating the environment of city and to apply the model to Ansan city in order to verify the applicability and reasonableness of the developed model.

Ansan is a satellite city located in the Seoul Metropolitan Region (SMR), and is the first planned city according to urban planning measure in Korea in 1976. More specifically, the city is established by Banwol New Industrial City Development Plan, which was announced in 1976 as a part of the Second National Land Development Plan, in order to disperse the growing population and industry concentrated in Seoul. As a result, many inappropriate industrial facilities in Seoul had been relocated to Ansan.

Figure 1 Key map of Ansan City



2. The Development of Urban Environmental Assessment Model

The concept of sustainability this paper deals with is quite broad and abstract. Considering that the structure of a city is closely related with every element of a society, it could be very hard to assess a certain city's sustainability through the process of systematizing and modeling. Thus, this study intends to develop a more precise and practical city assessment model with three basic modules diversified.

The first one, DPSER Module views a city as a systematic structure. In this module, a city is understood as it responds to various factors like human activities, the amount of environmental load generated, environmental conditions resulting from the environmental load, the influence of changed environment, and human response to the change.

In the second one, Stage Module, cities are variedly placed according to the stages of economic, political, and social development and to the different period of time. Environmental problems and prescriptions against them are also shown differently in each time period. Since sustainability means harmony among all time periods of past, present, and future in this module, the development of city assessment model, here, should consider diverse phenomena turning up in each time period.

Finally, " Spatial Scale Module" differs in its development pattern and environmental load according to the size of each city and to the developer, national or urban. National policies and urban policies can affect each other. Therefore, this module will help to figure out city development pattern and relationship among city components that can be varied due to space scale.

2.1 Components of the City Assessment Model

2.1.1 DPSER Module

DSPER Module is a comprehensive assessment model for urban environmental management. It has not been long that the indicators of this assessment model were widely used for public policies. In the late 1960s, many developed countries competitively introduced social indicators including "Social Indicator around Living Standard and Welfare" of UN Social Development Institute. Since the 1980s, more specific indicators of the model had been developed as society became more conscious of a quality of life.

Starting from "Korea's Social Indicator" in 1979, there have been a number of studies performed, and recently more specialized indicators like social welfare indicator and culture indicator were tried. In case of city-related indicators, individual indicators in a certain sector of city, such as environmental indicator, residential areas planning indicator, park green zone indicator are partly being studied. Indicators like housing indicator and environmental indicator are being studied as a part of the social indicator. Korea's environmental indicators have established environmental standard to each environmental element.

At the Conference of Environmental Ministries in the early 1990s, OECD (Organization for Economic Cooperation and Development) proposed to systematize principal indicators in accordance with PSR structure. PSR represents: first, pressure on the environment from emitted pollutants and exhausted natural resources, second, change of state due to pressure, and third, response against all pressures. Since then, there had been several changes with regard to the development of environmental indicators.[1]

Lee-Yoon (1998), in this indicator system, suggested DPSR structure which contains Driving Force Indicator and Pressure Indicator. This system tells Driving Force, which causes emitting of environmental pressure material in the fields of society, economy and politics, from Pressure, that is emitting of the material which human activities generate. With help of this system we can more specifically figure out the relationship among environmental constituents as well as among society, economy and politics, the three basic environmental causes.

DSPER structure this study suggests adds Effect to the Lee-Yoon(1998)'s DPSR system. While

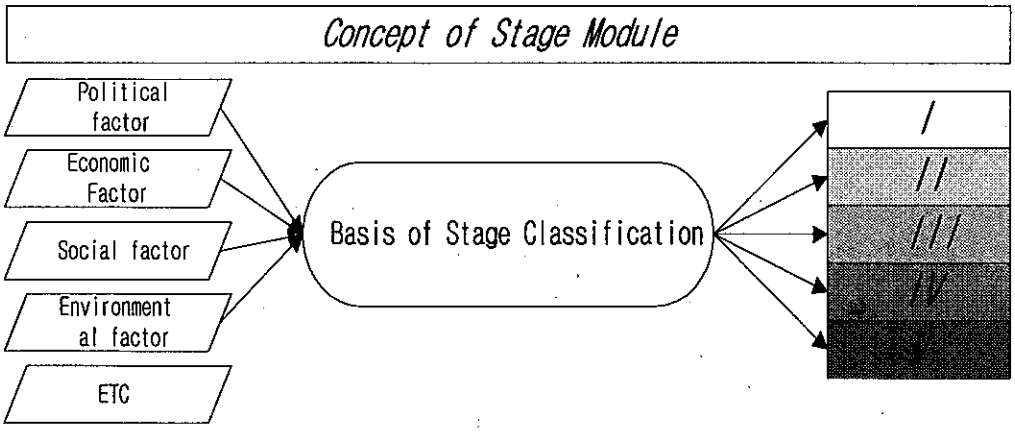
[1] Since the necessity of indicator development was clarified on the Chapter 40 of Agenda 21 in Rio Summit in 1992, practical work was under way by CSD and DPCSD. Especially the term Pressure in PSR was changed into Driving Force in order to properly institute indicators, taking society, economy, and institute all into consideration (UNCSD, 1995).

indicator represents the present situation, a model helps to predict the future and change direction. In the sustainable assessment model, comprehending the effect of environmental changes is necessary to predict changes in the future. In other words, to assess sustainability of a city, it is necessary to understand the effects on the urban environment but those on the global environment are also beginning to be discussed. The IPCC (International Panel on Climate Change) has three working groups: WG1 to study present situation of climate change, WG2 to study effects from climate change, and WG3 to study about alternatives to reduce climate change (IPCC, 1992). Here again the analysis on the Effect as well as on the State of the present environmental situation is to make sure of policies which will reduce green house effect at the international level and to draw attention to climate change (UNEP, 1998).

Among DPSER Modules, this study contains Effect, in that it is necessary for modeling the assessment system and also in that effects should be grasped to predict future changes and to build policies for the changes. However, the study can be inconsistent because effects can hardly be calculated, existent study is quite limited, a huge number of data are needed, and the methods are varied (UNEP, 1998). Even though it has limitation of time, labor, and data, not only national but beyond national level, this study had to embrace Effect, since it is necessary to comprehend the effect in the assessment of city sustainability. As a result, instead of traditional assessment system which vertically discusses individual environmental elements like pollution, national environment, and agreeableness, this study centers around ecological aspects, that is the relationship between "inherited natural environment", and "human beings taking its advantage.

In other words, it is based on the DSPER structure, which here can represent human activities under the social economic background (Driving Force), environmental load from those activities (Pressure), environmental State these cause, and the Effect due to environmental changes, and Response from human beings.

Figure 2 Concept of stage module



2.1.2 Stage Module

Urban development patterns and environment policy responses can be varied according to political and economical backgrounds, and the characteristics of environmental problems occurring. Also environmental problems are different in every stage of development, and so the response is.

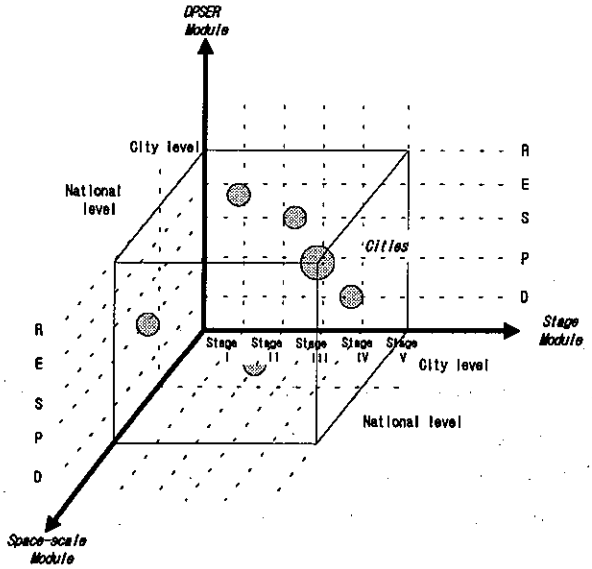
2.1.3 Space-Scale Module

For a city to be planned and developed in a sustainable way, there should be a system at the level of national government which requires sustainability from the very beginning of city planning and an assessment system to check. The driving force of national development is mainly from economic, political, social effects. In addition, different from the US where individual states have full rein of decision making, Korea needs consideration and or comparison at the level of national government even in assessing sustainability of a city. Thus for exact assessment of city sustainability, it is necessary to understand city development history at the national level and to locate it at the city level. Considering the difference in development patterns, applied policies, and the extent of environment problems between big cities and smaller ones, in comparing the size of cities, DPSERs should reflect different space scales.

2.2 Concept of the Assessment Model

Sustainability a city is placed in the three-dimensional graph consisting of DSPER module, Stage Module, and Space-Scale Module. Only by considering all these three modules, the assessment of city sustainability can best reflect the comprehensive, interactive relationship between the city and the environment .

Figure 3 Relationship between assessment sections and contents in DPSER Module

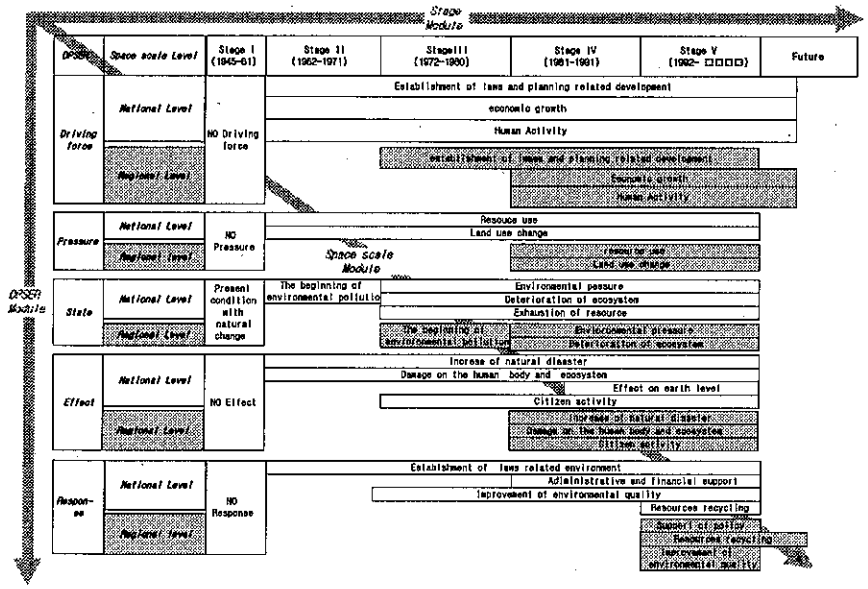


The next step is to decide which specific sections in a target city to be assessed. Figure 4 shows the relationship between assessment sections and their contents. Assessment sections are presented, classifying the relationship among city components in terms of DPSER. It shows that the assessment of each national and city by space-scale module can be differently staged in the Stage Module.

As for the contents of the assessment sections, the driving force is related to laws and plans, economic development, and human activities, all of which cause increasing use of energy and natural resources, and the change of land use. The environmental conditions are accordingly changed resulting in increased environmental load, deteriorated ecological system, and depleted natural resources. This changed environment, in return, inflicts a blow on human life and crops, and further on the entire globe, which will naturally increase natural disasters. To address this, we institute environment-related laws, provide support through policies and administration, and make efforts for better environmental quality and recycling.

In order to redefine and examine the concept of an evaluation model developed above, the model was applied to Ansan both at the national level and at the city level. Its results are shown in Figure 4.

Figure 4 Application of evaluation framework and sections



First of all, the national and city levels defined in DPSER module are set as the major axes of the evaluation system. Then, the evaluation sector of DPSER is applied to each of five stages, which were divided based on political, economic, social, and environmental issues as described in the stage module. For instance, at the national level of the driving force sector, development-related laws and plans, economic growth, and human activities began to pressure environment from the stage module stage two.

As for Ansan at a city level, development-related plans were established in stage three according to a policy implemented at the national level. Then, economic growth and urban human activities began in stage four. In the pressure sector, an environmental pressure attributable to the driving force sector led to various developments and economic growth, which resulted in increased use of resources and energy consumption beginning from stage two. National land development projects resulted in drastic changes in land use. In case of Ansan at a city level, the implementation of plans caused developments. Use of resources increased and land use began to change from stage four, where human activities begin.

As described, the national level and the city level, which are segmented according to the space size module in each sector of DPSER module, showed different driving forces and pressures in each stage. It was confirmed that the national level and the city level interact and make developments. It was also revealed that the contents and level of impact vary in each stage of the stage module.

2.3 Application & Establishment of Individual Indicators

Earlier, components and concept of evaluation model, inter-relations between the nation and Ansan in the evaluation model, and their positions in the model were reviewed.

In order to evaluate urbanization and sustainability of Ansan in specific, direct data need to be secured. To this end, individual indicators by evaluation area that are actually applicable were set. As the defined individual indicators are indicators actually applied in evaluating Ansan, it is better to have indicators that are specific and able to secure practical data. However, qualitative issues including policies and plans such as driving force section and response section would be replaced with a review of their contents or impact. Application results are as follows.

2.3.1 Driving Forces: The Case of Ansan

□ National-Level

- Establishment of Planning and Law related Development

In 1982, the Korean government developed several new cities around the city of Seoul to address over-concentration of Seoul Metropolitan Region. As an effort to disperse factories and population in Seoul area, Banwol new city, the origin of Ansan new city, was then developed. In addition, central government extensively initiated the introduction of ecosystem conservation policies including "Environment Conservation Act" in 1981 and reinforced actions against environment pollution. However, the government built nuclear power generation facilities to cope with explosive increase of energy demand as well as to stabilize energy supply.

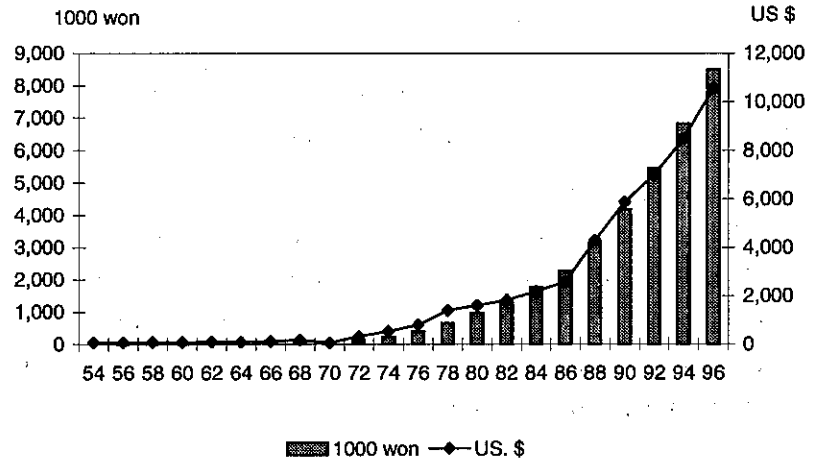
"The Third Land Development Plan" announced in 1992 seeks to harmonize development and environment with an objective to aim ecological development that values the harmony between development and conservation. However, laws, policies, and plans intended for urbanization and

industrialization in South Korea pursued growth-driven development policies without considering environment capacity. Environment conservation actions and development plans were initiated separately without close inter-relations. Entire society became resource & energy consumption-driven due to unplanned and unreasonable land use structure and development plans. A series of South Korea policies and plans mentioned above acts as a driving force giving a great pressure to the present state.

- Economic Growth

For the past five decades since the independence from Japanese colonization, despite political and social upheaval, South Korea achieved economic growth consistently and made remarkable achievement such as recording per capita income of over 10,000 US dollars and joining OECD.

Figure 5 The Growth of Per Capita GNP in South Korea, 1950s – 1990s



Source: National Statistic Office (various years).

As for GDP per annum, GDP was slightly over 100 billion dollars in 1970 but grew to 380.7 billion dollars in 1994, 456.5 billion dollars in 1995, 484.4 billion dollars in 1996, and 442.6 billion dollars in 1997. When the "National Land Construction Planning Act" came into effect in 1962, with the development of the Ulsan Industrial Complex as a start, many industrial complexes including Pohang, Masan, and Changwon were designated and developed.

□ Regional-Level

- Establishment of Planning related Development

Ansan, the first city to be developed according to urban planning in Korea in 1976, is based on Banwol New Industrial City Development Plan, which was announced in 1976 as a part of the Second National Land Development Plan to disperse ever-worsening population and industry concentration in the capital city Seoul. Since then, Banwol New City Re-organization Plan was

developed in 1985 and the city was promoted to Ansan in 1986. The revision of Banwol Special Region and Siwha District Development Master Plan were announced in 1986 and the construction of Siwha District began in 1987.

Kojan District implementation plan, the Phase 2 of development project of Ansan New City, was approved in 1992 and is under planning. With the incorporation of Ongjin Taeboo-myon (40.843㎢) and Hwasung-kun Banwol-myon (13.21㎢) in 1994, administration district has been changed. In 1995, a part of Hwajung-dong, Sooamg Changsan, and Changha-dong (10.79㎢) in Siheung city were incorporated into administration district.

- Human Activity

a. Population Growth

In Ansan city, natural increase rate is 2.0% and social population increase rate is 14.8%. This shows that key driver of population increase is inflow from other areas. Population density in 1996 was 3,684 persons/㎢, which was higher than 467.8 persons/㎢ nationwide and 809.8 persons/㎢ in Kyonggi province

Table 1 Population Density of Ansan City, 1996

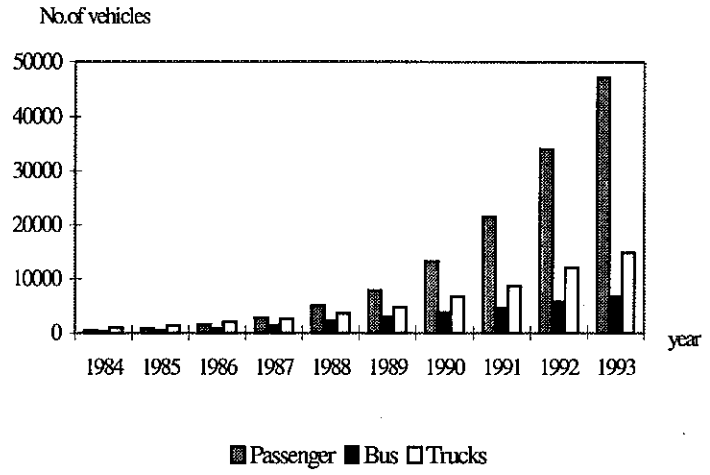
	ANSAN	NATIONWIDE	KYUNGGI-DO
Total population(person)	533,293	46,433,920	8,190,938
Total area(km2)	144.77	99,268.34	10,114.55
Population density(persons/km2)	3,684	467.8	809.8

Source: Office of Statistics (1997), Korea Statistics Annual , Kyunggi-do (1997), Key Statistics of Provincial Policy, Ansan city (1998, 1994), Ansan Statistics Annual.

b. Registration of Motor Vehicles

Along with population growth, higher road rates to some extent contributed to increase the use of automobiles. Regarding registered vehicles, the number of passenger cars in Ansan increased by twenty-fold, buses grew by more than 10 times, and trucks also rose by three times in the past decade. It is about five times higher compared to entire Kyunggi province and about nine times higher compared to nationwide. Such a sharp increase in automobile is due to a higher dependency on automobile of commuters, especially workers employed in the neighboring industrial complexes. Hence, it can be said that the demand for the car in this city is higher than that in other city

Figure 6 Registration of motor vehicles in Ansan, 1984 – 1993



Source: Ansan city (1998, 1994).

Table 2 Registered vehicles in Ansan city, 1996

	ANSAN	NATIONWIDE	KYONGGI-DO
Registered vehicles(unit)	127,496	9,553,000	1,810,000
Total area(km2)	144.77	99,268.34	10,114.55
Registered vehicles(unit/km2)	880.7	96.2	179.0

Source: NSO(1997), Korea Statistics Annual , Kyunggi-do(1997),
Key Statistics of Provincial Policy, Ansan city (1998, 1994), Ansan Statistics Annual

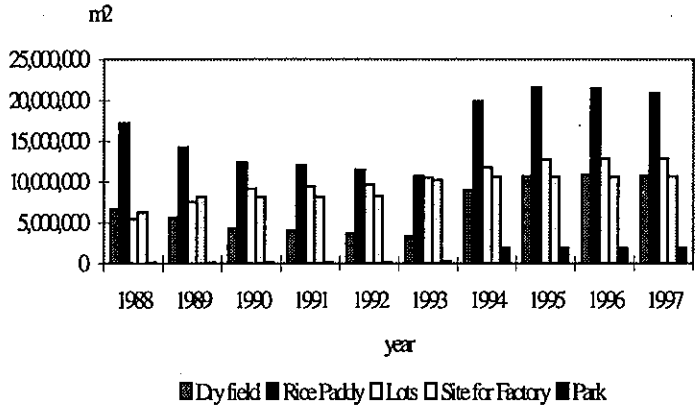
2.3.2 Environmental Pressure in Ansan

- Change of Land Use

• Land Use Change by Category

The environmental pressure in Ansan can be witnessed from the changed pattern of land use. From 1988 to 1993, dry field and rice paddy had decreased gradually increased except 1994 due to change of administrative district. Lots and factory sites were on a steady rise but are not increasing further since 1994. This is because although administrative district was expanded in 1994, the development of Ansan is not completed as of now and many sites are under development. Therefore, the area of lots and factory sites is not increasing for the time being. However, it is expected that the development of Kojan Zone, which is under development planning, is likely to increase lots sharply.

Figure 7. Change of land use in Ansan, 1988 - 1997



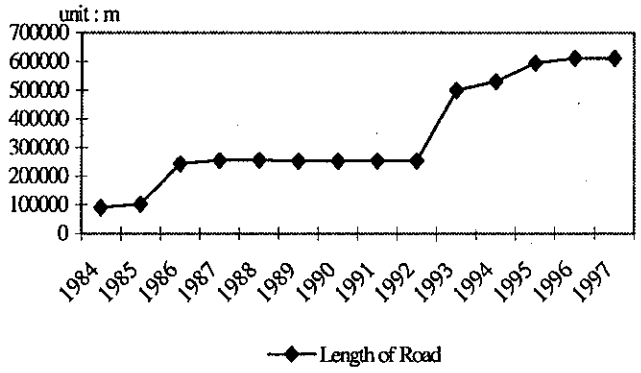
Source: Ansan city (1998, 1994).

- Length of Road

In order to facilitate traffic and resolve its problems caused by increased use of automobiles, roads will be extended constantly. The construction of roads results in disconnection and destruction of existing habitats and have a negative impact on ecosystem and bio-diversity.

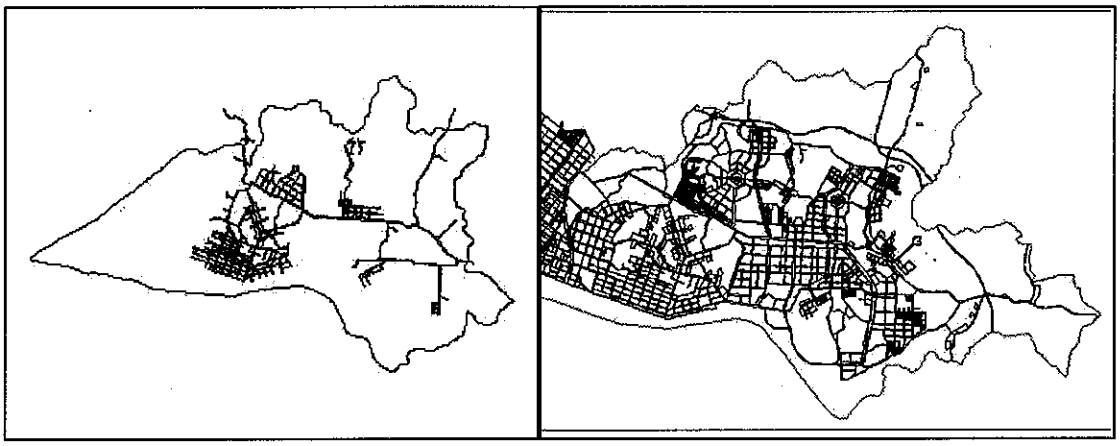
There was a 2.4-fold increase from 251km in 1988 to 611km in 1997 Figure 8. The fact that road extension increased 1.5 times from 55,778km in 1988 to 84,968km in 1997 nationwide suggests that road extension increase rate in Ansan is exceptionally high.

Figure 8 Length of road in Ansan, 1984 - 1997



Source: Ansan city (1998, 1994, 1992,1990).

Figure 9 Change of road condition in Ansan, 1987 - 1997

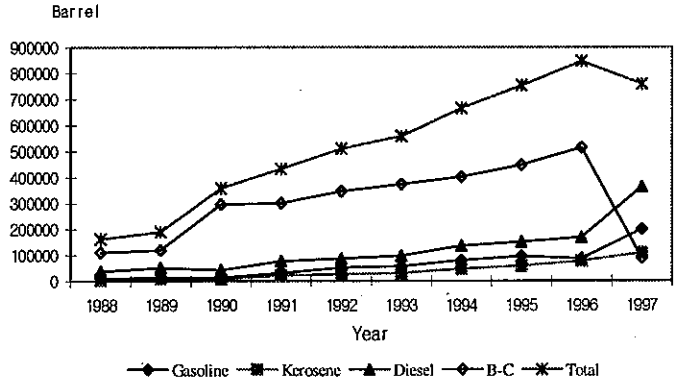


❑ Use of Resources

• Oil Consumption

Oil consumption is on a steady rise. In 1997, the consumption of gasoline and kerosene has increased sharply. Population and vehicle users in Ansan are growing sharply than other cities. Pressure on oil consumption is high because industrial complexes are major oil consumers.

Figure 10 Oil consumption in Ansan, 1988 - 1997

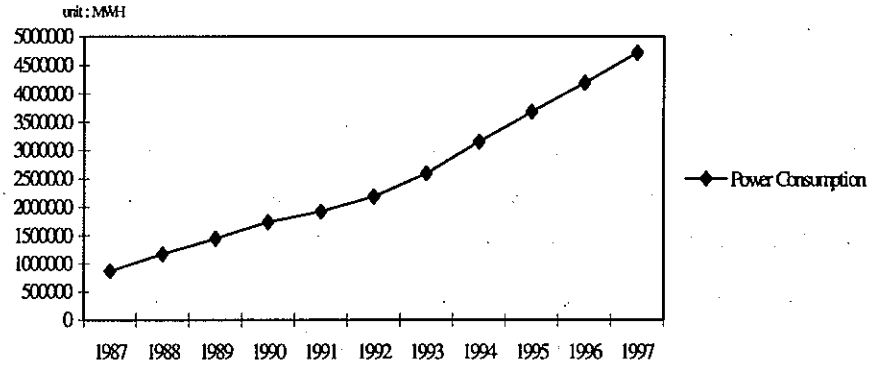


Source: Ansan city (1998, 1994, 1992, 1990).

• Power Consumption

As the city's electricity consumption is high compared to other cities due to total population and the number of households in driving force and industrial complex developments, the consumption has been on a steady rise since its promotion to a city in 1987.

Figure 11. Power consumption in Ansan, 1987 – 1997

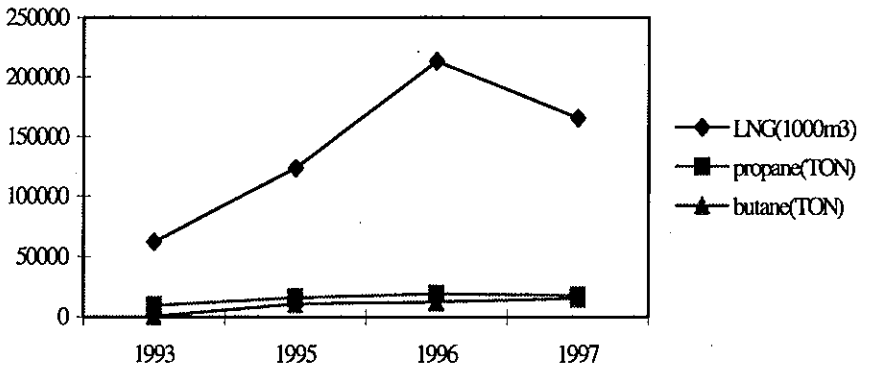


Source: Ansan city (1998, 1994, 1992, 1990).

- Gas Supply

The consumption of propane and butane was relatively stable, but that of LNG has risen from 1993 through 1996 and began to decline in 1997.

Figure 12 Gas Supply in Ansan, 1993 – 1997



Source: Ansan city (1994, 1998).

2.3.3 Current Environmental States in Ansan

Ecosystem is affected greatly by pressure-generating factors such as human activities, change of land use, and use of resources and changes the quality of life and the level of awareness significantly.

□ Ecosystem

The most important issue in evaluating an ecosystem is to consider qualitative and distribution aspects

as well as quantitative aspect. The amount of green area in a city needs to be identified regarding quantitative aspect and the naturalness of an ecosystem needs to be measured for qualitative aspect. As for distribution aspect, continuity and isolation of living creatures need to be surveyed.

- Quantitative Aspect

In order to measure the quantity of green area, landcover classification was done based on remote-sensing data of Ansan in 1987, 1992 and 1997. Landcover classification categorized land into forest, water, agricultural area, built-up area, bare soil and wetland.

The result showed that forest area has decreased by 6.7 percent, from 35.8 percent in 1987 to 29.1 percent in 1997. Agriculture land has also declined 5.2 percent, from 22.3 percent in 1987 to about 17.1 percent in 1997. Meanwhile, built-up area accounted for only 8.8 percent in 1987. However, it has increased by 4.9 times to 43.6 percent in 1997.

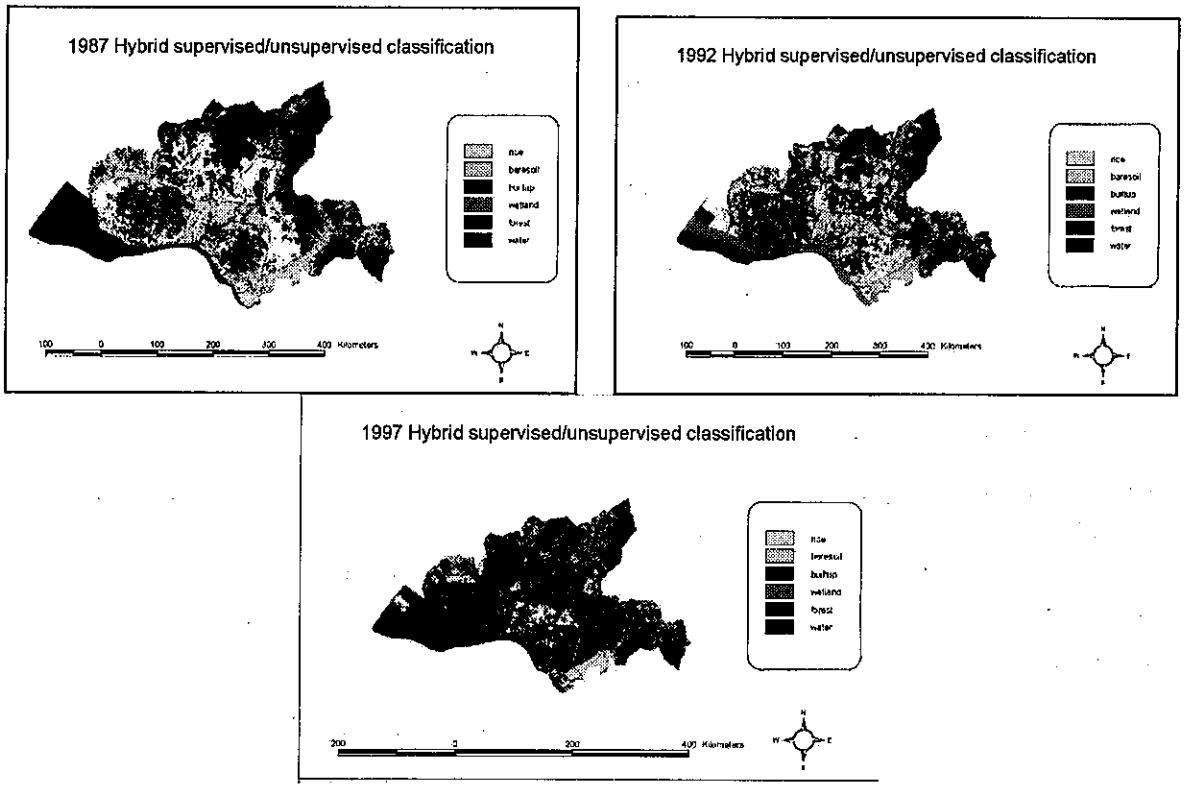
In overall, in 1987, agricultural area and forest area, which may be described as green areas, accounted for 58.1 percent or over half of entire area in Ansan area. However, in 1997, they have declined sharply, accounting for only 46.2 percent of total area. On the other hand, built-up area and road area, which are urbanized areas, were only 8.8 percent of total area in 1987, but they have shown a 4.9-fold growth to 43.6 percent of entire area in 1997

As it was explained in driving forces, Ansan underwent much development since the 1980s according to an industrialization policy. As a result, land use change and population increase were significant in terms of pressure. In addition, in a landcover classification to find out the state of 1987, 1992 and 1997 from the impact of pressure, above results were generated.

Table 3 The Share of Landcover Classification Area in 1987 –1997

	1987		1992		1997	
	Area(Km^2)	%	Area(Km^2)	%	Area(Km^2)	%
Water	14.4	12.8	5.7	4.9	6.2	5.8
Rice	25.1	22.3	31.4	27.2	18.1	17.1
Wetland	0.0	0.0	10.4	9.0	0.0	0.0
Forest	40.4	35.8	37.1	32.1	30.8	29.1
Built-up	10.0	8.8	19.4	16.8	46.2	43.6
Bare-soil	22.7	20.2	11.4	9.8	4.7	4.4
Total	112.6	100.0	115.4	100 .0	106.0	100.0

Figure 13Result of Hybrid Supervised/ Unsupervised Classification in 1987, 1992, and 1997

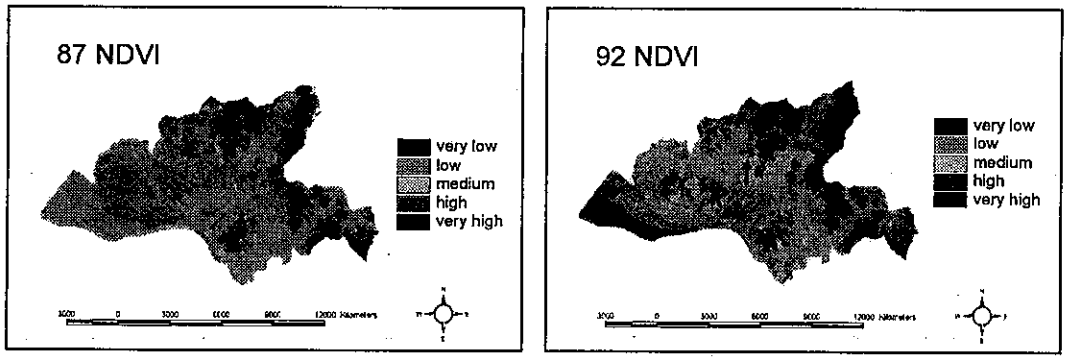


- Qualitative Aspect

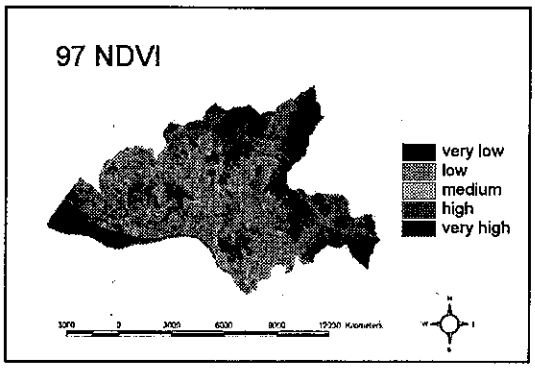
a. NDVI[2]

The result shows that NDVI has dropped since the 1980s when urbanization and industrialization took place actively in Ansan. It could be also seen that NDVI has dropped mostly in areas where development was concentrated including central part of the city and Banwol industrial complex.

Figure 14 The Change of NDVI, 1987 - 1997



[2] In order to measure the quality of green area, landcover classification was done based on remote-sensing data of Ansan in 1987, 1992 and 1997. In these figures, blue area is low-NDVI area, gray area represents average-NDVI area, and green area indicates high-NDVI area.



b. Degree of Green Naturality

The survey on the degree of green naturality in Ansan shows that Grade 1 (or urbanized area) accounts for 37 units (48%), while Grade 2 (or agricultural area) occupies a quarter of Ansan with 23 units (29.8%). This is followed by forest or grades 6, 7, and 8 that account for 20.7% of total areas. Grading shows that there is no area over level 8 at all that requires protection. This indicates that naturalness of forest is extremely low.

Table 4 Present condition of Degree of Green Naturality in Ansan

Classification	1	2	3	4	5	6	7	8	9	10	0	Total mesh (number)
Number of mesh	37	23	0	1	0	12	4	0	0	0	0	77

Source: Ministry of Environment (1990).

Average Degree of Green Naturality (DGN), which shows the features of development area, is 2.4 in Ansan. It is understood as green naturalness is low and a significant development is underway. It was also analyzed that present plant volume is 163,200 tons and its production is 47,240 tons/year in Ansan city.

Table 5. Degree of Green Naturality, Present Plant Volume and Production in Ansan city

	Area of administrative district(km^2)	Population (person)	Population density (person/km^2)	Total mesh (number)	Average DGN	Present plant volume (t)	Present plant volume/area (t/km^2)	Production (t)
Total	144.77	533,293	3,686	77	2.4	163,200	372.96	47,240

Source: Ansan city (1997), Ansan Statistics Annual

- Distribution Aspect

As for distribution aspect of an ecosystem, continuity and isolation of living creatures in Ansan

were surveyed. Isolation refers to the dispersion of places where living creatures can live. Data to evaluate isolation are collected by dividing forest, dry field, paddy field, orchid, and park into patches and calculating their sizes. Then, based on the range of sizes categorized according to certain criteria, the number of relevant patches are calculated and the degree of isolation is measured. Continuity refers to how continuously habitats are located and indicates the degree of disconnection of existing habitats or living creatures' movement due to road or urban development. The data to evaluate continuity are collected based on a network continuity formula that was presented by Forman & Godron(1986) showing the degree of nodes connected by corridors. Continuity is calculated by dividing the case study area into lattice of 250 m, setting L as the total of lines linked to eight nodes of surrounding green areas for each node, and setting Lmax as the number of lines when entire nodes in the case study are continuous.

a. Continuity Evaluation

Continuity of Ansan is 43.2%. The ratio of green area (forests, dry and paddy fields, and parks) was 71% in 1986 and 56.5% in 1997, which was relatively higher than other cities.[3] It suggests that continuity is high because green areas are found in metropolitan area as well as in suburban area. However, continuity is likely to decline due to on-going urban development.

Table 6 Continuity Evaluation in Ansan

CITY	CONNECTED LINES AT A NODE-①	8	7	6	5	4	3	2	1	ACTUAL CONTINUOUS LINES	POTENTIAL CONTINUOUS LINES	CONTINUITY (%)
Ansan	Nodes for ①	477	56	84	121	110	113	76	60			
	Total lines	3816	392	504	605	440	339	152	60	6308	14592	43.2

Source: Dong-Kun Lee & So-Won Yoon (1998).

In pressure indicator, continuity is relatively high while human activity, energy consumption, and change of land use are higher than other cities because Ansan is a planned city and its green system is slightly different from that of other cities in South Korea. Green area is not disconnected but continued because wide buffer green areas were developed in outer part of roads.

b. Isolation Evaluation

In comparing cities, when small patches are found more, there has been more pressure on environment such as urbanization and use of resources. This means that isolation is greater. In Ansan, 30.8% of patches were in size of 0.02-0.05㎢. Patches larger than 8 ㎢were also high with 0.4%. In addition, patches were distributed evenly from 0.02㎢to 0.5㎢. In other words, the urbanization of is still in progress. Therefore, the isolation of patches is less than other cities.

[3] By 1996, the ratio of green area in Seoul is 33.7 percent.

Table 7 Isolation Evaluation in Ansan

PATCH SIZE (㎢)	< 0.02	0.02< - <0.05	0.05< - <0.1	0.1< - <0.5	0.5< - <1	1< - <4	4< - <8	8<-
Ansan (%)	18.0	30.8	22.6	24.4	1.5	2.6	-	0.4

Source: Dong-Kun Lee & So-Won Yoon (1998).

❑ Environment Pressure

• Air

As Ansan has been planned as an industrial city, when the sectoral polluters of each air pollutant were analyzed, TSP and SO_2 were from industry and NO_2 was from transportation and industry.

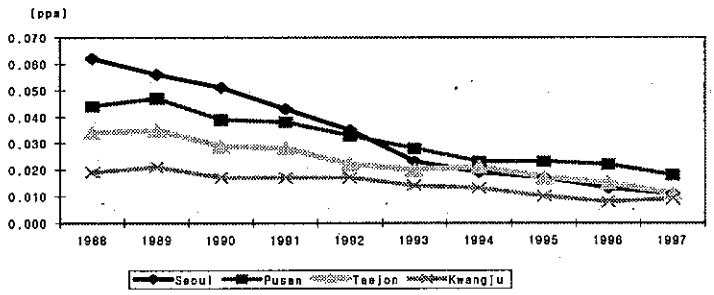
Table 8 The Level of Air Pollutants by Sector in Ansan

SECTOR	TSP		SO_2		NO_2	
	Korea	Ansan	Korea	Ansan	Korea	Ansan
Industry	62.2	78.1	67.8	84.0	42.5	40.1
Heating	19.4	19.7	19.7	5.3	6.7	1.7
Transportation	18.4	12.5	12.5	10.7	50.8	58.2

Source: Ansan City (1998, 1994).

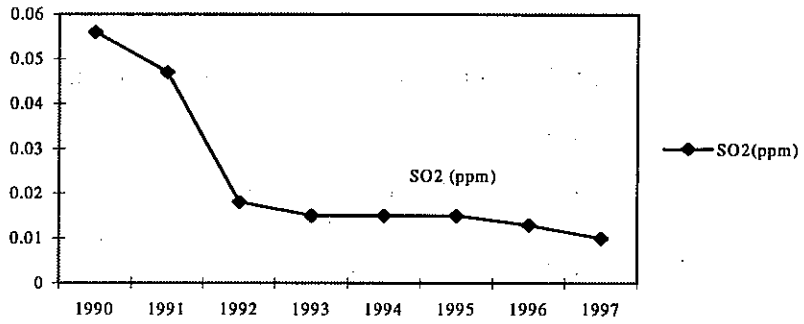
Concentration of sulfurous acid gas in the air of major cities has been declining continuously thanks to supply of low-sulfur gas and a regulation forcing to use "clean" fuel. In particular, concentration of SO_2 dropped sharply in large cities that had been highly polluted. Such a substantial reduction is largely to a responsive air conservation policy that is required to meets both Korean environmental requirements (annual average: less than 0.03ppm) and the WHO-recommended requirements (0.019ppm).

Figure 15 SO_2 Concentrations in Major Korean Cities



Source : the Ministry of Environment(1998)

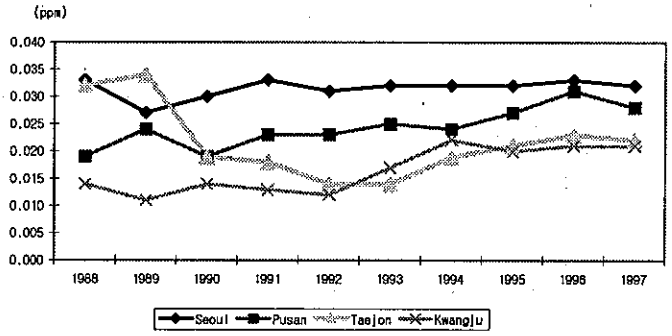
Figure 16 Level of SO_2 concentrations in Ansan



Source: Ministry of Environment (1998).

The concentration of NO_2 of major cities tends to rise slightly without a substantial change. High income-driven increased automobiles of driving force, greater pressure for energy consumption due to increased human activities, and pursuit of convenient consumption life are main causes of greater NO_2 contamination.

Figure 17. NO_2 Concentrations in Major Korean Cities



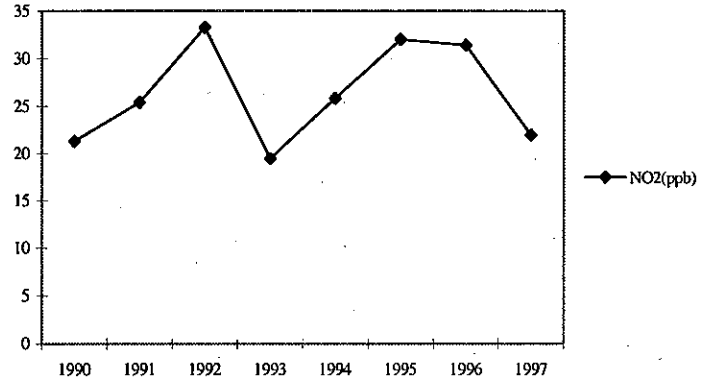
Source: Ministry of Environment (1998) Environment Statistic Annual Report

SO_2 and NO_2 has decreased sharply in the 1990s because the use of low sulfur-content oil and clean fuel became obligatory, the use of solid fuel was banned, and the permissible level of emission for air discharge facilities was reinforced in 1993 according to the national-level City Planning Act Implementation Order Article 15, Air Environment Conservation Act Article 10, and Air Environment Conservation Act Implementation Order. Thanks to these efforts, the levels of SO_2 and NO_2 have dropped since the late 1980s.

The full-operation of large-scale Siwha Industrial Complex and the sharp rise of vehicles that

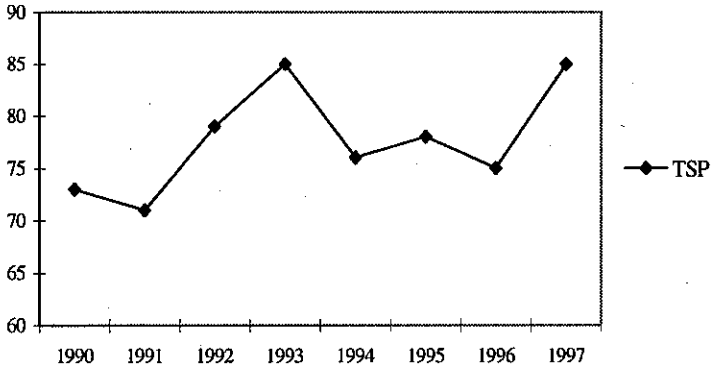
account for 40% of emission of entire pollutants are increasing the pressure. As the air pollution is likely to be serious in the future, appropriate actions are required.

Figure 18 Level of NO_2 Concentration in Ansan



Source: Ministry of Environment (1998).

Figure 19 Level of TSP in Ansan



Source: Ministry of Environment (1998) Environment Statistic Annual Report

- Water Quality

Waters from Ansan stream, Hwajung stream, and Banwol stream, the major water system of Ansan, are discharged with almost no self-purification process because water flow is small and stream route is short.

Pollution in these rivers is quite serious. In terms of BOD, all three streams in Ansan (Banwol stream: 21.3 mg/ℓ, Hwajong stream: 30.8 mg/ℓ, Ansan stream: 15.9 mg/ℓ) exceed water quality level V that makes daily life unpleasant so that the improvement of water pollution becomes very urgent.

Table 9 Condition of water pollution by stream, 1997

STREAM	PH	DO(MG/ℓ)	BOD(MG/ℓ)	COD(MG/ℓ)	SS(MG/ℓ)	LENGTH(M)
Banwol	7.16	4.06	21.31	60.84	15.06	4,675
Ansan	7.38	4.21	15.95	16.74	16.14	8,200
Hwajung	7.39	2.51	30.84	24.44	35.20	4,700
Singil	7.37	2.79	28.79	30.30	16.71	1,100

Source: Ansan City (1997).

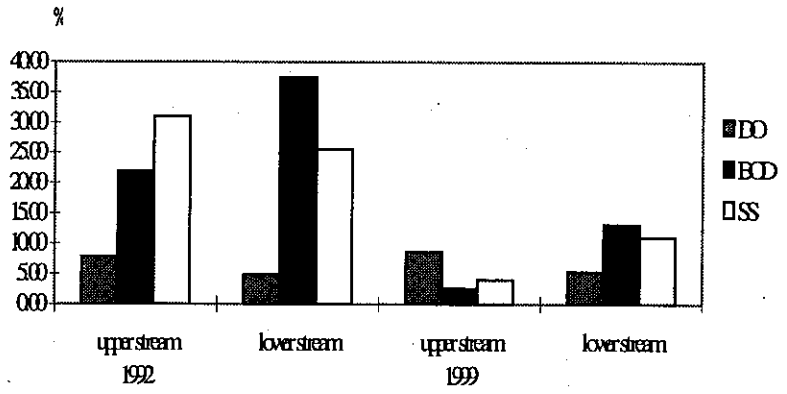
Table 10 Discharge of waste water, 1995

	NATIONAL	KYONGGI-DO	ANSAN
Total sewage(m3/day)	8,926,123	847,571	135,837
Total population(person)	44,608,726	7,811,468	507,952
Industrial sewage (ton/day/person)	0.20	0.11	0.27

Source: NSO (1997); Kyonggi-do (1997); Ansan city (1995).

Supply rate of sewage system in Ansan is nearly 100% processing entire sewage generated in the area. Therefore, a chance of water contamination caused by daily life sewage is very slim. However, plant sewage generated in Banwol Industrial Complex and Siwha Industrial Complex is 0.27 ton/day/person, which is twice as high as 0.11 ton/day/person in Kyonggi province, arousing concerns for water pollution by plant sewage.

Figure 20 The state of water pollution - Ansan Stream



However, it could be seen that the levels have declined sharply in January 1999 with sewage control GIS initiatives, plans to prevent discharge of sewage to streams by replacing poor pipes and surveying poor joints and leaking pipes, installation of joint sewage treatment facility, and the increase and enhancement of sewage treatment. Despite, BOD is much higher than environment standard level in downstream.

Figure 21. The state of water pollution - Hwajung Stream

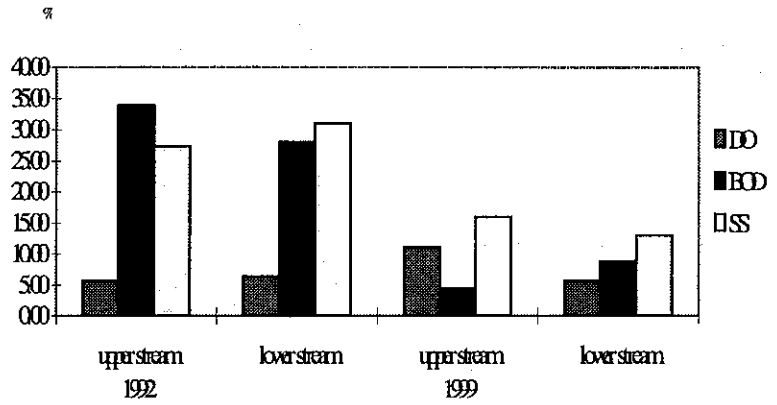
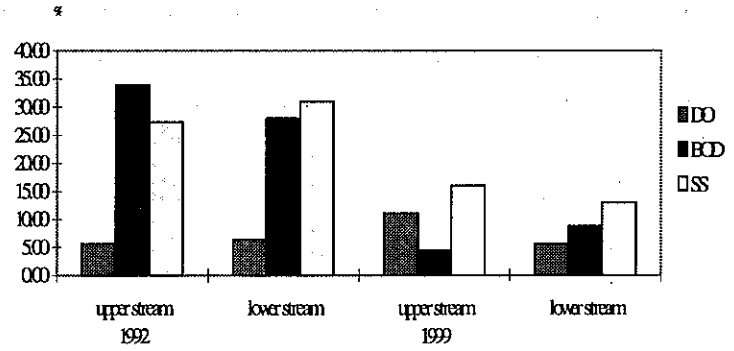


Figure 22. The state of water pollution - Banweal Stream



Source : Ansan City (1997, 1994) Ansan City Master Plan, Ansan city (1998, 1994), Ansan Statistics Annual

- Waste

The source of waste discharge was divided into house and workplace. Waste coming from house accounted for 38% of entire waste. In workplace segment, discharge from factory accounted for about 52% of waste from workplace. While waste from house accounts for a large portion in other cities, waste from workplace is greater in Ansan.

Daily life waste generated per day/person in Ansan is 0.81kg, which is less than 0.89kg in Kyonggi province. However, waste generated in business site & facility is 427 tons suggesting reduction of business site wastes and stimulation of recycling are necessary. Only 33.6% of daily life wastes is recycled, which is still slightly higher than 30.2% in Kyonggi province and 26.1% nationwide.

Table 11. Present condition waste in Ansan, 1996

	POPULATION (1000PERSONS)	UNIT (KG/PERSON/ DAY)	DAILY LIFE WASTE (TON/DAY)	WASTE GENERATED IN LIFE SITE & FACILITY (TON/DAY)	WASTE GENERATED IN BUSINESS SITE & FACILITY (TON/DAY)	CONSTRUCT WASTE (TON/DAY)
Amount of waste	517	0.81	420	83	427	67

Source: Ministry of Environment (1997), Nationwide Waste Generation and Disposal (1996)

- Amenity

- Per Capita Park Area

In Ansan, a total of 50 parks are planned covering 6,570,000 m^2. Park area ratio against Ansan administrative area of 144.770 Km^2 is 4.54%. Among them, 17 parks have been already developed covering 2,719,000 m^2. In terms of area, park development is 41.4%, which is significantly higher than other cities. Parks under development or yet to be developed are 31 sites (3,851,000 m^2). Among parks, neighborhood parks consist of the majority by 4,038,000 m^2, followed by city natural park of 2,532,000 m^2.

Table 12 Present condition of urban park in Ansan, 1996

	Total	Urban natural park	Neighborhood park	Children park	Cemetery park	Physical training park
Area ($1000m^2$)	6570	2532	4038	-	-	-
	50	5	45	-	-	-

Source: Kyonggi Province (1997) Dept. of urban planning inside data

As for per capita park area, it is 12.93 m^2/person in terms of planned parks. This exceeds requirement of 6 m^2/person in urban planning district. It is 5.35 m^2/person in terms of developed park, which is also near to the requirement of 6 m^2/person.

Table 13 Analysis of Park Area in Ansan, 1996

	ADMINISTRATIVE DISTRICT AREA(Km^2)	POPULATION (PERSON)	DENSITY (PERSON /K m^2)	PARK AREA (m^2)		PERCENTAGE OF PARK AREA (%)		PARK AREA PER PERSON (M^2/PERSON)	
Total	144.77	533,293	3686	6,570,000	2,719,000	4.54	1.88	12.93	5.35

Source: Kyonggi Province Government (1997).

2.3.4 The Environmental Effects on Ansan city

Increased use of driving force due to urbanization and industrialization led to a greater pressure on environment. This has resulted in many problems including increased environmental burden and the destruction of natural ecosystem. Consequently, the nature lost its self-purification function, and environment that used to give only benefits to us now has physical and human impact to the humankind.

However, impact analysis is difficult to calculate, and studies available today are limited in their scope. In addition, impact analysis requires extensive data and lacks consistency due to diverse methods. Likewise, this study requires a great amount of data, time, and manpower in order to analyze and evaluate impact.

❑ National level

As for national-level impact, increased natural disasters and environmental pollution have negative impact on agricultural crops, ecosystem, and bio-diversity and also affect climate.

- Increase of Natural Disasters

  Disasters can be divided into natural disasters and man-made disasters. Disasters in water resources are usually natural disasters. They are mostly caused by natural phenomena such as weather and climate and have an irresistible force that may not be overcome completely by the humankind.

Table 14 Economic loss and recovery cost due to natural disasters, 1993 - 1997

	AMOUNT OF DAMAGE (in million Korean Won)	RECOVERY COST (in million Korean Won)
1992	24,059.0	33,154.3
1993	197,114.3	296,336.9
1994	153,374.8	230,049.4
1995	601,151.7	867,056.2

1996	483,050.4	653,262.6
Average	291,750.0	415,971.9

Source: Ministry of Home Affairs (1993-1997)

Loss from damage increased from about 2.4 billion Won in 1992 to 48.3 billion Won in 1996. Casualty was 40 persons in 1992, 69 in 1993, 72 in 1994, 158 in 1995, and 77 in 1996. As for recovery cost, it required 33.1 billion Won in 1992, 867.0 billion Won in 1995, and 653.2 billion Won in 1996. There may be many factors responsible for the increase of disasters: inevitable natural causes including climate, topography, and geological features and man-made causes such as poor skills or negligence in efforts to use or overcome the nature.

Table 15 Damage of natural disaster by facility in Korea, 1992 - 1996

YEAR	DAMAGE COST BREAKDOWN (in million Korean Won)					
	Building	Shipping	Farmland	Public facility	Others	Total
1992	97.2	1,087.2	1,390.1	15,039.1	6,445.3	24,058.9
1993	1,172.0	10,616.3	10,066.1	153,403.8	21,856.1	197,114.3
1994	556.8	4,380.8	10,939.6	86,696.0	50,801.5	153,374.7
1995	4,958.6	6,959.3	61,034.0	434,300.9	93,899.0	601,151.9
1996	14,968.7	854.7	54,086.6	334,512.1	78,628.3	483,050.4
Average	4,350.7	4,779.7	27,503.3	204,790.4	50,326.0	291,750.0

Source: Ministry of Home Affairs (1993-1997).

- Damage on Humankind and Agricultural Crops

Damages on human being and agricultural crops accumulate in long-term rather than short-term. In the end, it incurs great loss and is difficult to seek countermeasures to address them. Water pollution mishaps that cause the most damage on humankind and agricultural crops have declined from 83 in 1995 to 65 in 1997. However, the damage from accumulated pollutants and transfer of impact due to ecosystem food chain may become greater.

Table 17 Type of Water Pollution Accident

	TOTAL	EMISSION OF OIL	CHANGE OF WATER ENVIRONMENT	EMISSION OF BAD MATERIAL	OTHERS
1995	83 (100 %)	34 (41.0%)	22 (26.5%)	12 (14.5%)	15 (18.0%)
1996	75 (100%)	39 (52.0%)	18 (24.0%)	6 (8.0%)	12 (16.0%)
1997	65 (100%)	37 (57.0%)	11 (17.0%)	10 (15.0%)	7 (11.0%)

Source: the Ministry of Environment, 1998, Environment White Book.

- Damage on Ecosystem and Biodiversity

As industrialization and urbanization change land use, reduce habitats, and affect ecosystem and bio-diversity, rare and endangered wild life are gradually declining.

Table 18. The Number of the Rare and Endangered Wild Life

	TOTAL	EXTERMINATED SPECIES	ENDANGERED SPECIES	RARE SPECIES	DECLINED SPECIES
Mammamlia	21	1	8	8	4
Birds	54	1	23	30	-
Amphibia. &Reptiles.	12	-	1	6	5
Fishes	29	1	3	18	7
Insect	24	-	1	23	-
Plant	39	3	7	25	4
Total	179	6	43	110	20

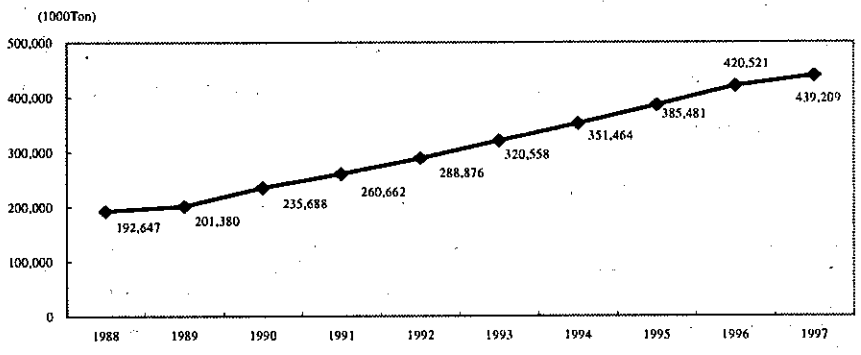
Source: the Ministry of Environment, 1998, Environment White Book.

- Damage on climate

a. Change of City Temperature

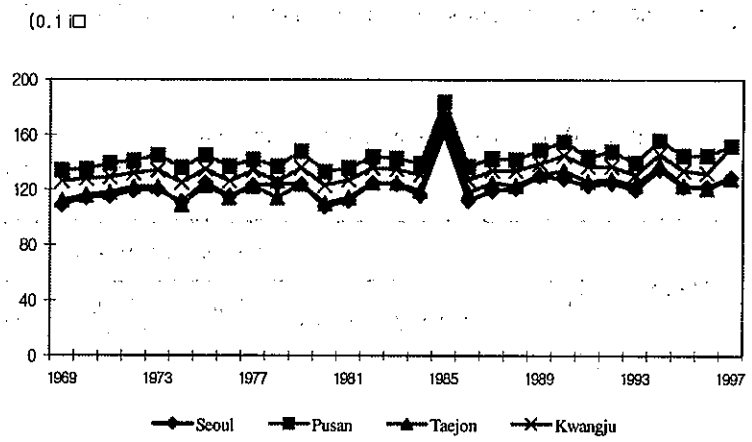
Growing air pollution is accelerating greenhouse effect. Emission of CO_2, a main cause of greenhouse effect, is on a consistent rise in Korea due to sharp increase of energy consumption led by industrial development, increased traffic, and improved living standard. It grew 9.6% annually from 1988 to 1997 or 2.3 times from 192.54 million tons to 439.21 million tons. As a result, although the temperatures of major cities in Korea are relatively normal, average temperatures of major cities - despite some fluctuations - increased by 1℃- 2℃ in overall from 1969 through 1997 due to greenhouse effect.

Figure 23. Emission of CO_2 in Korea



Source: http://www.me.go.kr/www/index.html

Figure 24. Average temperature of major cities in Korea



Source: www.me.go.kr/www/index.html

b. Change of Acidity in Rain

Rain reacts with carbonic acid gas in the air and supposed to be slightly acid. Sulfur oxides and nitrogen oxides emitted from air pollutants are dissolved by moisture in the air and further increases acidity of rain. Therefore, as the contamination by SO_2 and NO_2 increases, which was reviewed in State, acidity will rise. Acid rain is usually defined as rain lower than pH 5.6. Acidity during rainfall is closely associated with air pollution level (in particular sulfurous acid gas contamination). In 1996, acidity during rainfall in major cities was highest in Pusan with pH 5.1. Areas other than Pusan showed a normal level of acidity at pH 5.6 or higher. Nevertheless, development of countermeasures against damage by acid rain and plans to prevent air pollution are urgently required.

Table 19 Acidity of Rainfall in Major Cities

(unit : pH)

YEAR CITY	86	87	88	89	90	91	92	93	94	95	96
Seoul	5.3	5.1	5.7	5.6	5.0	5.4	5.3	5.4	5.4	5.8	5.7
Pusan	5.2	5.4	5.2	5.2	5.2	5.1	5.2	5.3	5.2	5.2	5.1
Taegu	5.4	5.3	5.6	5.3	5.7	5.9	5.6	5.5	5.6	5.7	5.6
Inchon	5.5	5.2	6.0	5.7	5.9	6.1	6.2	5.8	6.0	5.9	5.9
Kwangju	6.1	5.8	5.7	5.7	5.5	5.5	5.7	5.8	5.8	6.2	5.9
Taejon	5.4	5.5	5.7	5.8	5.4	5.6	5.7	5.5	5.7	5.9	5.8
Ulsan	5.2	4.9	5.1	5.6	5.6	5.7	5.6	5.6	5.4	5.3	5.7

Source: the Ministry of Environment (1997) Environmental statistic annual

❑ Regional Level

• Increase of Natural Disaster

At a city level, impact assessment is constrained in many ways, and there is hardly any data available.

Table 20 Damages from Storms and Floods

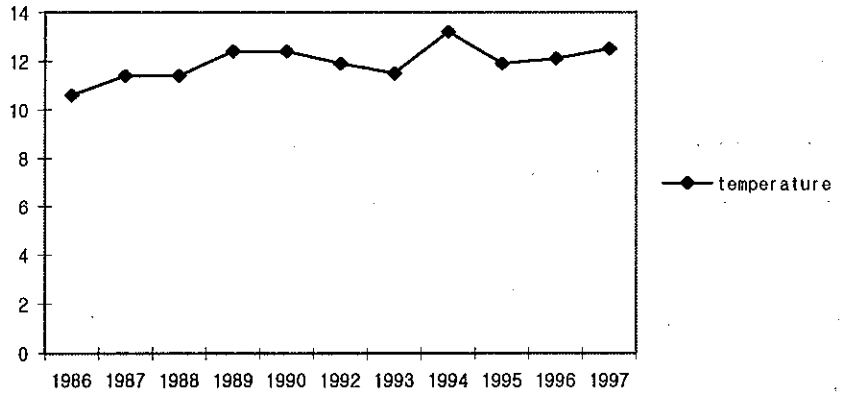
(unit : person, ha., thousand won)

YEAR	DEATH & MISSING	SUFFERES	FLOODED AREA	VALUE OF DAMAGE					
				Building	Shipping	Farming areas	Public Facilities	Other	Total
1992	-	-	60.3	-	-	-	-	-	
1993	-	-	-	-	-	-	-	-	
1994	-	-	-	-	-	-	-	-	
1995	-	-	-	44	44	-	-	-	88
1996	-	-	-	-	-	-	-	-	
1997	-	-		-	-	-	100,000	30,000	130,000

Source: Ansan city, Ansan Statistic Annual, 1997

Table 13 shows damages by storm and floods in Ansan. In 1995, it had affected building and shipping. Then in 1997, it has incurred a loss of 130 million Won on public facility and others .Temperature in Ansan has been relatively normal for about a decade from 1986 to 1997. Although it fluctuates each year, in general, there has been hardly any change except that it has increased by 1-2℃ in overall.

Figure 25 Average Temperature in Ansan



Source: Ansan city (1998, 1994), Ansan Statistics Annual

2.3.5 Responses

□ National level

• Change of Environmental Budget

Government's budget for environment has grown steadily since the 1980s. In 1997, environmental budget against GNP has increased by nine times and government budget has grown by eight times compared to 1980, indicating the growing importance and interest on environment. On the other hand, it includes cost that must be shouldered today in addressing environmental pollution and environmental mishaps caused by people's negligence of environment in the past. Therefore, if we start to reduce burden on environment and be considerate of environment even from now, cost involved would decrease, and it would be possible to invest more in enhancing the quality of environment.

Table 21 Environmental Budget in South Korea, 1980s – 1990s

	GNP		GOVERNMENT BUDGET		ENVIRONMENTAL BUDGET		THE MINISTRY OF ENVIRONMENT BUDGET		SHARE OF ENVIRONMENTAL BUDGET (%)	
	GNP	Rate of increase	Budget	Rate of increase	Budget	Rate of increase	Budget	Rate of increase	Share of GNP	Share of government budget
1980	368570	19.4	86478	86478	453	-	121	-	0.03	0.14
1985	793011	11.6	150003	150003	1300	27.1	421	22.7	0.05	0.28
1990	1782621	20.5	325369	325369	3447	37.1	1172	81.7	0.07	0.36
1991	2142399	20.2	393669	393669	4863	41.1	2718	131.9	0.13	0.69
1992	2387046	11.4	438421	438421	6138	26.2	1396	48.6	0.06	0.32
1993	2655179	11.2	511879	511879	7271	18.5	1887	35.2	0.07	0.37
1994	3037726	14.4	644575	644575	11612	59.7	4716	149.9	0.16	0.73
1995	3489793	14.9	745344	745344	17801	53.3	6729	42.6	0.19	0.90
1996	3864382	10.7	853083	853083	22406	25.9	8851	31.5	0.23	1.04
1997	4160179	7.7	983299	983299	27530	22.9	10802	22.0	0.26	1.10

Source: http://www.me.go.kr/www/index.html

❑ Regional level

a. Establishment of Act, Policy, Planning, and Standard

FIELD		MAJOR POLICIES AND PLANNING MEASURES
Environment	Air	• 1993.7.1. : Obligation of the use of the ultra-low sulfur oil and pure fuel • Prohibition of the use of the solid fuel • Intensification of permission criterion of emission in the atmosphere emission equipment - 1992.8.8.~94.12.31 : Application of the 1st stage permission criterion - 1995.1.1~1998.12.31 : Application of the 2nd stage permission criterion - after 1999.1.1 : Application of the 3rd stage permission criterion • Future plan - Extension of the technical and financial support according to the establishment, change and operation of the emission prohibition equipment - Establishment of the perfect air pollution prohibition equipment when the waste processing places are constructed - Research of the countermeasure to the fuel consumption of the heat-fusion power station that uses many fuels and the plan on the additional establishment of the prohibition equipment of the high efficient sulfuric acidification - Presently use soft coal that is the solid fuel mainly, light oil and B-C oil partly, and establish the FGD as the prohibition equipment of the sulfuric acidification materials
	Water Quality	• The plan to drive the sewage management G.I.S. : 1st stage - 1995~1998. The investigation of the actual condition of the sewage management and the sewage management using GIS : 2nd stage - 1998~2003. The investigation of the actual condition of the sewage management and the sewage management using GIS • 1985. The fundamental plan of the maintenance of the sewage in Ansan • 1992.6. The plan of the re-maintenance of the sewage in Ansan • The extension of the capacity of the sewage disposal plant and developing it highly : be enforced according to the plan of establishing the sewage disposal plant permanently 1999~2003 : The extension of the pipe of the dirty and waste water 1995~2003 : The specialization of the operator of the sewage disposal plant 1995~2003 : Introduction of the technical diagnosis system 1995~2003 : Establishment of the common disposal plant of the waste water in the factory Intensification of the waste water in the livestock industry 1999~2003 Establishment of the common disposal plant of the human excreta and the waste water in the livestock industry 1995~2003 The tree-planting of the ground
	Waste	• Extension of the supply of the waste collector 1994~2003 : Extension of the equipment that makes the food waste in apartment forage 1995~2003 : Extension of the common equipment that makes the forage 1995~2003 : Extension of the place that makes wastes reuse 1995~1998 : Establishment of the equipment that reduce the use of containment 1995~2003 : Establishment of the cremation place 1995~2003 : Expansion of the cleaning vehicles 1994~1997 : Establishment of the self reclamation places 1995~2003 : Establishment of the equipment that makes the food waste in apartment into the forage 1995, 1999. : Establishment of the common equipment that makes the forage 1995~2003 : Establishment of the cremation place 1990~2000 : Establishment of the place that makes wastes reuse 1995~2001 : Establishment of the self reclamation places • The plan of the excretion place • The excretion plan of the common house : Organization of the operator who excretes separately per the common house : Establishment of the equipment that makes the food into the forage and compost(Apartment) • The excretion plan of the usual house : Establishment of the separate collection boxes per alley • The plan of the resources reuse

	Open Space	• Construction of the botanical gardens • Maintenance of the park and green tract of land • Construction of the flower road and establishment of the flower boxes • Development of the movement planting the rose • Investigation of the environment and ecology of the forest 1998~1999 : Construction of the by-garden 1997~1998 : Construction of the bon-O garden 1997~1998 : Construction of the Kwan-san garden 1997~1998 : Construction of the Wonkojan garden
Industry		1995~2003 : Change and support of the prohibition equipment 1995~2003 : Establishment of T.M.S. 1995~1998 : Establishment of the heat fusion power plant F.G.D
Environmental Facility	Elementary	1995~2003 : Expansion of the vehicles that can clean the road surface under vacuum 1995~2003 : Expansion of the net that can measure the air pollution automatically 1995~2003 : Establishment of the environment institute(the weather bureau) 1995~2003 : Occupation of the green tract of land

b. Environmental Budget

Environmental budget of Ansan is spent for park afforestation expense related with health & living environment improvement, cleaning expense, and irrigation & sewage projects. It was able to reduce the budget by 8% from 32.8% of entire budget in 1995 to 24.1% in 1998. Still, it may be said that the share of environment budget out of entire budget is quite high.

Table 22 Environmental Budget of Ansan

YEAR	ENVIRONMENTAL BUDGET	TOTAL BUDGET
1995	65,488,829 (32.8%)	199,188,028
1996	68,952,441 (26.7%)	258,196,630
1997	81,083,935 (29.6%)	273,518,982
1998	63,721,050 (24.1%)	263,787,183

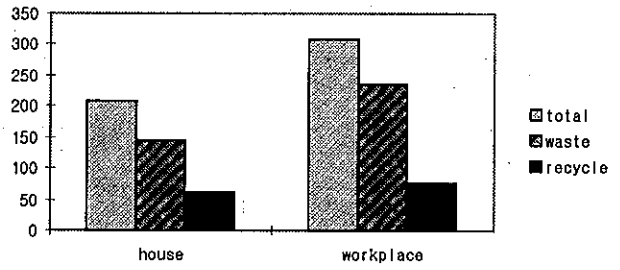
Source: Ansan City, Government Internal Data

- Re-use of Resources

a. Waste Recycling

Waste recycling rate in house was higher with 42.2%, while the rate in workplace was 31.9%. It is similar in Kyunggi province, with recycling rate for house being 42.8% and workplace 30.9%.

Figure 30 The amount of Waste Recycling (ton)



In addition, as a move to encourage reduction of waste generation and separate collection of recyclable goods, Ansan has also introduced volume-based garbage collection and separate garbage collection in 1995. Concerning domestice waste disposal in Ansan, the treatment is depended on one transhipment facility and one recycled goods warehouse, respectively.

Since the introduction of volume-based garbage collection and at the support of resident's active participation, per capita waste generation has declined by 29%. Dispersing the initial concerns, the system seems to be quite successful so far.

Table 24 Waste Emission Before and After of Introduction of Volume-based Garbage Collection

	BEFORE AVERAGE (1994)	AFTER AVERAGE (1997)	REMARKS
Waste emission	498	398	Against per capita waste generation : decrease 29%

Source: Ansan city, 1997, Municipal Government White Book

Furthermore, volume of garbage carried into capital area landfill was 387 tons/day before the introduction. Despite continuous increase of population, it has dropped to 244 tons/day in average in 1997 saving 897 million Won in cost involved with carrying the garbage into capital area landfill. Before the introduction of volume-based garbage system, cleaning expense self-sufficiency was merely 7%. However, in 1997 after three years since the introduction, it has risen to 40% reducing deficit in cleaning expense.

Table 25. Volume of garbage carried into capital area landfill (unit : ton)

	AVERAGE / DAY	TOTAL PER YEAR	CHARGE FOR CARRY INTO PER TON	CHARGE FOR CARRY INTO OF DAILY LIFE WASTER
Before (1994)	387	141255	5500 won	776million won
After (1997)	244	89060	17179 won	1530million won

Source: Ansan city (1997) Municipal government white book

As for discharge of recycling goods, it is now 145 tons/day, or a 42% jump compared to pre-introduction.

Table 26. Discharge of Recycling Goods

(unit : ton/day

	BEFORE AVERAGE(1994)	AFTER AVERAGE	REMARKS
Discharge of recycling goods	76	145	Against per capita waste generation : increase 42%

Source: Ansan city (1997) Municipal Government White Book

- Qualitative Improvement of Environment

a. Conservation Creation of Habitats

In order to present corresponding indicators for qualitative improvement of environment, change in continuity and isolation - the distribution aspect of ecosystem - was analyzed assuming that undeveloped parks would be developed and eco-bridges would be developed to connect green areas in parts that are disconnected today due to roads or urbanization to conserve and create habitats.

There are 10 undeveloped parks in Ansan. The analysis of continuity and isolation shows that continuity would increase by 1.1%, when seven sites out of many places where an ecosystem is disconnected are actually developed.

Table 27. Changed Continuity When Undeveloped Parks and Eco-bridge are Developed

	PAST CONTINUITY(%)	WHEN UNDEVELOPED PARK AND ECO-BRIDGE ARE DEVELOPED(%)
Ansan	43.2	44.3

Source: Dong-Kun Lee & So-Won Yoon(1998).

The change in isolation with the completion of undeveloped parks and the development of eco-bridge is shown in Table 19. It is desirable that with the completed development of undeveloped parks, isolation is changed in a direction of reduction in small patches and increase in the large patches. Compared to the present state, reduction rate is high in patches less than 0.1㎢ and patches larger than 0.1㎢ are slightly increasing.

Table 28. Changed Isolation After the Completed Development of Undeveloped Parks

PATCH SIZE (㎢)	< 0.02	0.02< - <0.05	0.05< - <0.1	0.1< - <0.5	0.5< - <1	1< - <4	4< - <8	8<-
Ansan[1] (%)	17.1 (-0.9)	30.8	21.8 (-0.8)	24.5 (0.1)	1.7 (0.2)	2.8 (0.2)	1.0 (1.0)	0.3 (-0.1)

Source: Dong-Kun Lee & So-Won Yoon(1998).

b. Sewage Facility

Ansan, which is developed as a new city development project since the late 1970s, is planned with a complete classification sewage facility. When Ansan was developed, planned population was 250,000. However, due to inflow of population from Seoul area and industrialization-led sharp rise of population, expansion of existing drainage pipeline, transit pump site, and sewage disposal

facility became inevitable. Accordingly, in June 1992, Ansan developed a large-scale facility expansion plan. Since then, the constructions of collection pipeline, transit pump site, and sewage disposal facility were launched in March 1993 and are underway today.

Table 29. Sewage system supply rate

YEAR	ADMINIST-RATIVE DISTRICT	DRAINING AREA	URBAN POPULATION	DRAINING POPULATION	RATE OF SEWEGE SERVICE		
					Draining Area	Draining population	Drain pipe
1986	73.92	28.6	127.231	115900	93.8	91.1	92.5
1987	73.92	29.4	162.569	115900	93.8	91.1	99.3
1988	74.26	29.4	171.420	165400	95.8	96.5	99.1
1989	74.85	29.4	202.051	194979	95.8	96.5	99.1
1990	74.79	30.2	252.157	233013	98.4	92.4	99.2
1991	74.88	30.2	309.921	289023	98.4	93	99.1
1992	74.88	-	-	-	-	96.0	-
1993	77.45	30.40	401100	398000	99.2	98.9	-
1994	131.92	30.40	460380	425475	96.1	92.4	-

Source: Ansan city (1990, 1994, 1998) Ansan statistic annual

- Citizen Activity

a. Change of Environment-related Disputes.

With the increase of industrial production driven by high degree of industrialization and expansion of Korean economy, discharge of environmental pollutants has also grown. In fact, factors that may cause environmental pollution are continuously increasing. There is a change in land use due to continuous development of natural environment such as river or streams to meet people's ever-growing demand for clean water and clean air and continuously increasing demand for water and to resolve mismatch of supply and demand of water between regions and large-scale development projects such as industrial complexes and residential areas. Moreover, in light of local autonomy system introduced in 1995 and the era of $10,000 per capita GNP, people's desire for comfortable environment is ever-growing, which in turn would stimulate more environment-related disputes.

Table 30. Civil Petitions Related with Environment Pollution Damages in Ansan

	TOTAL	AIR		WATER			NOISE & VIBRATION		OTHERS
		Odor from factory	Odor from daily life	Dust	Illegal discharge	Others	Noise from factory	Noise from daily life	
1999	84	4	13	3	2	4	6	49	3
1998	41	0	9	1	0	0	4	26	1
1997	46	6	5	5	1	1	7	12	9

Source: Ansan city, Dept. of Environmental Protect Inside Data.

Civil petitions related with environment pollution damages in Ansan are described in the following table. The number of civil petitions in 1999 has doubled compared to 1997 and 1998, while civil petitions in noise & vibration ranked top. According to an official of Ansan government, nearly 100% of filed civil petitions has been addressed.

When compared with nationwide data, among 252 complaints filed for mediation from 1991 and 1998, noise & vibration accounted most with 73% or 183 cases, showing a pattern similar to Ansan. It was followed by air with 14% or 36 cases. In 1998, noise & vibration accounted 91% of complaints filed. They were complaints mostly for building or mental damages/loss due to noise & vibration caused by construction of apartments or infrastructure such as roads.

Table 31 Application and Management of Dispute Mediation Accident

(unit : number)

	TOTAL	'91~'92	'93	'94	'95	'96	'97	'98
Acceptance	252	5	43	15	30	50	47	62
Total	252	5	44	28	38	62	72	90
Management	216	4	31	20	26	37	44	54
in progress	36	-	-	-	-	-	-	36

Source: http://www.iin.co.kr/pdf/env1/pdf/2-6.pdf

Table 32 Pollution Sector, 1991 - 1998

(unit: number)

	TOTAL	NOISE&VIBRATION	AIR	WATER QUALITY	OCEAN
1991-1992	5	1	1	3	-
1993	43	21 (49)	9 (21)	5 (12)	8 (18)
1994	15	10 (67)	2 (13)	3 (20)	-
1995	30	18 (60)	4 (13)	7 (24)	1 (3)
1996	50	41 (82)	7 (14)	2 (4)	-
1997	47	36 (77)	9 (19)	2 (4)	-
1998	62	56 (91)	4 (6)	2 (3)	-
Total (%)	252 (100)	183 (73)	36 (14)	24 (10)	9 (3)

Source: http://www.iin.co.kr/pdf/env1/pdf/2-6.pdf

3. Conclusions

As the concentration of population and economic activities into Seoul had been accelerated since the 1970s, the Korean government had initiated several policy measures to alleviate a wide range of urban problems in the capital city, including housing shortage, industrial pollution, and environmental degradation. The government established the city of Ansan as a planned city, aiming sustainable city

with self-reliance in terms of urban function.

Given these backgrounds, Ansan was planned an environment-conscious city with a higher urban amenity. Several characteristics of the industrial parks, which is located in the periphery of the city, deserve great interests in terms of its environmental consideration. The industrial park is strictly separated to built-up areas with buffer-area and there had been an attempt to improve the quality of water resources by the separated sewage treatment between run-off and wastewater and the adoption of recycling system.

In parallel with subsequent urban development projects, the city, however, has experienced the sharp increase of population, from 162, 569 in 1987 to 551, 310 in 1997. In 2016, the number of the city's population is forecasted to reach almost one million. Such a raid growth of population causes a wide variety of environmental problems with regards to air, water, and other pollution.

Concerning air pollution, Ansan so far maintains better conditions compared to other cities in terms of several indicators (SO_2 , NO_2 , and TSP). Yet, the city is quite venerable to in the case that the factories neighboring to the city illegally discharge toxic chemicals or encounter the malfunction of pollution-prevention equipment. Another environmental challenge is derived from a newly-established industrial park, Si-Hwa industrial estate, where large-scaled manufacturing plants are being located. In addition, the growing number of automobiles is expected to compound the deterioration of air pollution the city further. In response to the growing air pollution problem, the city government is seeking the structural shift of the city's industry toward environment-friendly development and encouraging the use of clean-fuel in both domestic and industrial sector. Moreover, other city's efforts include the enhancement of monitoring on air pollution across the city, the promotion of alternative transport modes (i.g. bicycle), and the extension of urban greenery.

Concerning water pollution, the city of Ansan experiences the substantial discharge of wastewater from both domestic and industrial sectors, although the city had installed a sewage treatment system that separated run-off and wastewater. As a result, the river streams in this city have been considerably contaminated. The aging sewage system and illegal discharge of industrial wastewater compounded the degradation of water resources in Ansan. Furthermore, most river streams in the city lost self-purification function due to short river-flow and little run-off. Facing such water-related pollution, the city government is extensively expanding the capacity of sewage treatment and industrial wastewater.

Ansan is increasingly significant that this industrial city is expected to be a leading city in the future development of southwestern region in Korea. In particular, the city initiated "Local Agenda 21" in the name of "Evergreen Ansan 21,"after the Rio-round in 1992. The main contents of this local initiative include the precautionary measures towards sustainable urban environment.

Following the consensus-building among various environmental stakeholders through a series of public hearings and consultations, the city established the comprehensive environment-related chapters in 1997. According this environment-related guideline, the city government should be mainly responsible for all environment-related issues. More specifically, these environmental chapters not

only clarify municipal environmental administration by nature, but also update the comprehensive environment plan every five years. In addition, the chapters enable citizen to access to environment-related information and provide legal basis for environment-related financing by adoption of user-polluter.

The case study on Ansan's urban environment demonstrates the city is still positioned in better environmental state in terms of urban amenity, despite the substantial pressure on urban environment from rapid growth in both population and industry, and recent automobile increase. The study furthermore suggests that Ansan can be a good model of sustainable urban development if the city enhances efforts to respond the pressing environmental issues as well as to incorporate various demands of stakeholders into urban environmental management.

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